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ABSTRACT

The Swedish National Board of Education sent a study group to the United States to collect information concerning trends on the educational uses of computers and, drawing upon what was learned on the trip to America, to determine the future role of computers in Swedish education. Visits were made to approximately 20 American institutions such as universities, research institutes, and government bureaus which have substantial computer oriented programs underway. Information was gathered about the computer: 1) as a calculator; 2) related to administrative tasks; 3) applied to instruction; 4) used for simulations; and 5) utilized for research and documentation. The resulting Swedish pilot study aimed to identify problem areas, clarify the uses of the computer, and develop a cost estimate for introducing computers into Swedish education. (PB)

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The Computer in Schools - A Summary

Åke Andersson
Educational Consultant

National Board of Education
STOCKHOLM
1973

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National Board of Education
S-106 42 STOCKHOLM

The DIS-group
Educational Consultant
Åke Andersson

"The Computer in Schools"

- A Summary

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Foreword

It would be difficult to overstate the commercial and administrative importance of computer technology. Although serious use was not made of the computer until the 1950s, computer technology has already left its mark on developments in a wide range of sectors in society.

But there is one large and important sector of society, schools and the educational sector, in which relatively little use has been made of computer technology. The Swedish school system comprises 1.5 million students, 100,000 teachers and 5,000 schools with a total budget of some Skr. 9 billion.

Research and development work has been in progress since the end of the 1950s in the sector which for the sake of simplicity will here be termed "the computer in school" (abbreviated DIS in Swedish). The computer activities involved here are many and various and concern many different spheres of the educational system.

Work in the DIS sector in Sweden began in 1966. Following a study visit to the USA, a working party including representative of the National Swedish Board of Education and the National Swedish Office for Administrative Rationalization and Economy drew up proposals for experimental activities with what is termed Computer Managed Instruction, but these proposals failed to materialize because no appropriation was made by the Government.

In October 1970 an internal working party known as the DIS group was set up at the National Board of Education to investigate the role of the computer in schools. This group compiled a preliminary study which was completed in March 1971. The National Board of Education decided that this study should continue into a second phase (pilot study 2) constituting an amplification and extension of pilot study 1, i.e.

- a survey of the uses to which computers are being put today within the educational sector
- an evaluation of the experience gained
- a basis for further action

In the USA extensive experiments have been in progress within the DIS sector since the end of the 1950s. The National Board of Education attached great importance to ascertaining the experience that had been gained in the course of these experiments and it was therefore

decided to send certain members of the DIS group on a study tour of the USA. This tour took place in September and October 1971 and the results were presented in a report dated 1971-12-15.

The second phase of the investigation concluded with the presentation in March 1972 of pilot study 2.

The use of computers in schools is a pre-eminently international topic. Sweden participates in international conferences and projects under the auspices of the Council of Europe and OECD. The DIS group has established a wide range of international contacts and has been able in the course of its own work to draw on the wealth of experience that has been gained abroad, particularly in the USA. The National Board of Education therefore feels that the reports so far compiled by the DIS group are of international relevance and can contribute to the international exchange of experience within this sector.

The present English report is a summary of the USA report and pilot study 2.

Stockholm

February 1973

Sixten Marklund
Professor
Head of Bureau of
Research and Development
National Board of Education

1973-02-15

STUDY VISIT TO THE USA, SEPTEMBER - OCTOBER 1971

Background

In October 1970 an internal working party was set up to investigate the role of the computer in schools as part of the National Board of Education project "The Computer in the Educational Sector" (L 4:2). The group compiled a pilot study[1] which was presented at a meeting of the secretariat on 29.3.71. It was decided at this meeting that the project work should continue into a second phase (Pilot Study 2) constituting an elucidation and amplification of Pilot Study 1, i.e.

- giving a survey of the use at present being made of computers in the educational sector
- evaluating the experience gained
- presenting a basis for further action

Since April 1971 the DIS group has consisted of:

Åke Andersson, L, chairman
Ingemar Bartholdsson, educational adviser, UA
Björn von Heland, head of division, P
(Leif Gouiedo, head of department. P)
Lennart Larsson, UY
Lars Olov Ånséhn, organizational adviser, Us

The DIS sector calls for considerable resources in the way of machinery, computer programmes and systems staff. It is therefore imperative that development trends within the sector be observed at an early stage so as to prevent misguided long-term investments.

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1) "The Computer in Schools (DIS) - Pilot Study 1" (dated 9.12.70)

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The USA is the leading country in the DIS sector. Experiments there began as early as the late fifties, i.e. about five years earlier than in any other country. Consequently the USA possesses experience of activities throughout the whole of the DIS sector.

A study visit to the USA was therefore regarded as a necessary precondition for the success of the survey work being conducted under the project. The visit is therefore to be regarded as part of the project work.

Aims

The principal aim of the visit to the USA was to collect knowledge and experience concerning development trends and experience concerning development trends and innovations within the sectors described in the first pilot study report:

1. The computer as calculator (e.g. in certain technical and scientific subjects).

2. The computer applied to administrative tasks in schools (e.g. pupil registration, timetable construction).

3. The computer applied to tasks of pedagogical administration (the computer as a steering, supporting and control instrument in a teaching process).

4. Computer-based simulation, e.g. in connection with economic games, decision games, vocational guidance and careers decisions.

5. Computer-assisted instruction (CAI)

6. The computer as used in information, documentation and research.

Itinerary

The visit covered the period 18.9 - 9.10.71. A detailed description of the institutions visited and persons contacted is given on pages 9 - 12.

Study visit to the USA, 18.9 - 9.10.71

Day	Place	Institution	Persons contacted	Topic
Monday 20.9	New York	Teachers College Columbia University	Dr Roger Myers	ECES (Computer based vocational guidance)
Tues. 21.9	Washington	US Office of Education	Mr Timothy King Mr Clarence Fogelström Dr James Moss	General presentation The computer in the handicap sector
		National Science Foundation	Dr Andrew Molnar	Computer activities in post-secondary education
Weds. 22.9	Washington	US office of Education	Dr Richard Otte Dr Ward Mason	Computer experiments Regional labs
Thur. 23.9	Boston	Harvard University, Computing Center	Mr Dave D Dicks	Administrative data processing
		Wentworth Technical Institute	Mr J G Steves Mr James Marellano	Computer Science
Fri. 24.9	Boston	Graduate School of Business Administration	Dr Wilbert A Pinkerton, Jr	Computer based simulation
		Massachusetts Institute of Technology (M.I.T.)	Dr Zenon S Zannetos Dr Michael S Scott Morton	Further development of CAI
		Alfred P. Sloan School of Management	Mr James L Linderman Dr Edwin Taylor	University administration and data processing

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Day	Place	Institution	Persons contacted	Topic
Monday 27.9	Ann Arbor (ÅA)	University of Michigan	Dr Karl Zinn Dr Alfred Maley Dr David D Starks Dr Wayne K Davis Dr Norman Bell Mr Alan Emery	Computer based simulation General presentation
		University of Michigan, Center for Research on Learning and Teaching		Simulating Research (Evaluation) Experience for School Personnel
	Pittsburgh (LG)	University of Pittsburgh	Dr Jack K Greenberg Director J Cieutat	Computer based evaluation methodology
		American Institutes for Research	Dr Mike Rosenfeld	Computer based goal description
		Carnegie-Mellon University	Dr Allan Newell	Search processes with computers
Tue. 28.9	Chicago (ÅA)	Board of Education	Mr Henry Strassburg, Assistant Superintendent Mr Warrance Rosenthal	The computer in the school municipality
Tue. 28.9	Minneapolis (LG)	Minnesota School Districts, Data Processing Joint Board	Director Thomas C Campbell	The TIES project
Wed. 29.9	Palo Alto	Stanford University Institute for mathematical studies in the social sciences	Mrs Grace Kanz	CAI (Suppes' experiment)
		Brentwood School Artificial Intelligence Laboratory	Mrs Grace Kanz Dr J Kolby	CAI for handicapped children

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Day	Place	Institution	Persons contacted	Topic
Thur. 30.9	Palo Alto	Stanford Research Institute	Mr Gordon Parker	Presentation of SRI's activities
			Dr Sylvan Rubin	The computer in the teaching of physics
			Dr Abraham Waksman	The computer and the handicapped
			Mr Thomas C Thomas	Educational Research Policy
Fri. 1.10	Palo Alto	American Institutes for Research	Dr David V Tiedeman	ISVD (the Syo project)
			Dr William M Shanner	Project PLAN (the CMI project)
		Stanford University	Dr Bob Fletcher Mr Bruce Harlow	CAI (Suppes' experiments)
Mon. 4.10	Santa Monica	Systems Development Corporation	Dr David C Aaronson Dr S Coulson	PLANIT, CAI, CMI
Tue. 5.10	Santa Monica	Southwest Regional Laboratories (SWRL)	Dr Richard Schutz	IMS (the CMI project)
		Control Data Corp.	Mr David J Showalter	Computer tests
Wed. 6.10	Houston	NASA (ÅA)	Mr Bob Driver	Simulation
		Education Service Center (LG)	Mr T S Hancock Mr G Ferrel Morris Mr Jay Justice Mr D Dooley	Computer services

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Day	Place	Institution	Persons contacted	Topic
Thur. 7.10	Tallahassee	Florida State University	Dr Paul F Merril Dr Philip Duchatell	Presentation of computer activities at the University
			Dr G Bransom Dr Robert M Gagné	General presentation
Fri. 8.10	Miami	Miami Dade Junior College	Mr Floyd Howe Mr Joseph Duerstock	The computer in planning, administration etc.
Thur. 14.10	Washington (ÅA)	Office of Education	Dr J Tresher Dr Charles Missar	ERIC
		Rand Corporation	Dr Roger Levian	Outline
Fri. 15.10	Washington (ÅA)	Office of Education	Dr Richard Otte	Computer experiments in Texas
	Dartmouth (LG)	Dartmouth College	Director Thomas Byrne Director E Kurtz	Information systems

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SUMMARY OF THE USA REPORT - BY SECTORS

The computer as calculator

At many schools and institutions the computer was first used as an aid to calculation. As a rule experiments began in technical subjects, mathematics or physics. At Dartmouth College, for instance, problem solution using computers was made obligatory for newly enrolled students during the period 1965-1966. Four years later 80 per cent of the students were using computers for different purposes, including problem solution (Byrne).

In many schools computer orientation or education goes hand in hand with the utilization of the computer as an aid to calculation. In connection with a course in computer techniques at high schools in Chicago, three of the five physics laboratory periods every week are devoted to training students in computer techniques at high schools in Chicago, three of the five physics laboratory periods every week are devoted to training students in computer techniques which are directly applicable to physics experiments. In economic subjects pupils are trained to compile computer based registers (Strassburg).

The computer applied to tasks of school administration

In many parts of the USA, extensive work is in progress on the utilization of the computer for administrative routines. Thus a data bank on teachers and students (on-line, real time basis) has been established at the University of Chicago (Strassburg).

When a computer is to be installed, it is of fundamental importance to chart the administrative functioning of the school and to investigate carefully the environment in which the computer is to be placed. Strassburg feels that the construction of a computer based school administrative system should start with a teacher and personnel register. A corresponding system should subsequently be established for the pupils. Only after this has been done can accounting, salary routines etc. come into question.

The TIES project in Minnesota is another comprehensive system covering 29 school district with 200 primary and 80 secondary schools. TIES includes such diverse functions as administration, teaching and research (Campbell). A similar but even larger data network centred in Houston, Texas, covers 600 schools with 500 000 pupils. Collaboration here is above all concerned with the hardware in the system. Standardized data common to all school districts within the system do not yet exist (Hancock).

At Florida State University the computer is used for "resource scheduling", i.e. efforts are made with the help of the computer to distribute and monitor the teaching materials, premises and equipment used in the school system, which are often pooled (Merril).

In Dartmouth the computer is used for estimating resource requirements (teachers, premises etc.) by making forecasts of the numbers enrolling for different courses as well as the number of enrolled students who can be expected to complete the course successfully (Byrne).

Opinions vary concerning the use of the computer for timetable construction. Some experts (Linderman, Howe and Duerstock) are quite sceptical while others (Strassburg) are of the opinion that there are no longer any problems involved in the use of computers for this purpose.

The computer applied to pedagogical administrative tasks

The use of the computer for pedagogical administrative tasks, i.e. as a steering and control member in the teaching or learning process, is usually termed CMI (Computer Managed Instruction).

It is hard to say what individual data are suitable for inclusion in a CMI system. Some experts (Coulson et al.) feel that the achievement and test data successively accumulated by the CMI system are enough. Others, however, feel that data concerning the pupil's socio-economic background, mental and emotional maturity should also be included. For reasons of official discretion it is difficult to include data of this kind in the CMI system (Strassburg).

Critics feel that insufficient insight has been acquired into the components of the teaching and learning process for the computer to be used as a steering and control member. Even the prediction of the next step or item to be completed by the pupil is a formidable problem. There are perhaps 20 possible so-called next steps (Scott-Morton).

Experts who favour the CMI idea (Davies, Shanner, Coulson, Duchatell), however, put forward the following arguments in its defence

1. CMI relieves the teacher of many time-consuming routines of a non-teaching character.

2. Compared to conventional teaching, CMI gives the pupil more opportunities per day of devoting himself to individualized studies and exercises.

But CMI presupposes a meticulous analysis of the activities occurring in the classroom, so that the CMI system can be tailored exactly to suit the current teaching and learning situation. Another difficulty is to provide the pupils with other forms of individualizing material than the printed variety.

Both teachers and pupils are thought to be in favour of the CMI idea. New CMI projects will probably be launched, even though the shortage of funds for grants is at present a serious obstacle.

"Automated testing" can be regarded as a subsidiary sector of CMI. A great deal of time has been spent at Florida State University using the computer to present current items to the pupils, work out scores and "diagnose" the pupil's knowledge on the basis of his answers. An optimistic view is taken of the possibilities of developing and refining the techniques of computer testing. Efforts are being made in so-called sequence testing to reduce the testing time and test work. The computer programme takes into account not only the preceding answers given by the pupil but also the certainty and knowledge displayed by him. It also registers the time taken by the pupil to answer. On the basis of preceding answers, test scores and the quality of the answer, the computer determines which test item is to be offered to the pupil in the next steps (Merril).

Computer-managed simulation

In economic subjects the computer is already regarded as a necessary aid to economic games. This need not necessarily entail the simulation of a particular activity. It may be enough to programme the decision data needed by two rival teams for each new move confronting them. Another possibility is for computer-based simulation models to be used as an aid to give the pupil an insight into the decision situations often confronting the manager of a firm (Pinkerton).

At the University of Michigan interesting experiments are in progress in the utilization of computer resources for simulation games in environment conservation (Maley). Simulation of a particular natural resources can make it easier for a pupil to understand how that resource functions. Formerly the abundance of variables made it extremely difficult to illustrate and study a particular environment using conventional methods. Computerbased simulation is in fact needed in many contexts so as to be able to teach certain points realistically (instead of lecturing about them). Of course one is bound for various reasons, above all financial ones, to simplify the game in relation to the reality behind it. But excessive simplification means that only a small transfer effect can be obtained.

Maley contends that computer-based simulation offers three advantages: 1. It provides more concrete experience of a situation which cannot be reproduced in the classroom. 2. It increases pupil motivation. 3. The pupil can work through the computer-based game regardless of time and the availability of a teacher.

Another simulation experiment is being conducted at the University of Michigan, where computer-based simulation models

are being used with a view to teaching experts to evaluate educational programmes, types of schools and school systems. Here, then, the aim is to investigate and if possible predict the value of a particular instruction. The project leader is given the task of simulating out the most suitable methods, routes or alternatives for solving a particular problem with due regard among other things to a given budget. The model can include upwards of a hundred variables. The computer makes it possible to handle highly complex relations. One of the advantages of computer-based simulation is that the result can be read off immediately. Normally evaluation within the school sector takes far too long (Collet).

Many computer-based experiments are in progress in the study and vocational guidance sector with a view to making pupils more motivated for careers decisions and at the same time offering them a proper chance of obtaining information from several occupational sectors. Elements of simulation are involved here too (Myers, Tiedeman).

Computer-assisted instruction (CAI)

The first experiments with CAI began at Stanford University as early as 1964. A relatively complicated and expensive technical apparatus was used to begin with, most of the teacher's functions being taken over by the computer programme. In the second phase simple equipment was adopted (remote writer only) and only certain portions of the subject matter were conveyed to the pupil via the computer (drill and practice). The important task in this case is to select the portions suitable for computer learning (Fletcher). Of all the CAI programmes tested at Stanford (mathematics, reading, logical algebra, language arts, Basic English, Russian), the Russian experiment was the most successful. Demonstrable differences were found in favour of the CAI group as well as a heavy reduction in the drop-out percentage (Kanz).

Many experts (Scott-Morton et al.) maintain, however, that the computer as an aid to teaching has been utilized in a highly **conventional** manner. Often the programmed textbook has been made to serve as the basis of the computer programme. In other words, no use whatsoever has been made of the potential resources of the computer. The CAI programme has also been criticized on the grounds that it has not been integrated with classroom teaching (in the subject concerned) or with other teaching aids. Zenon S Zannetos has shown one way out of these difficulties in his experiments using the computer for concept learning and for the study of **relations** between concepts. The pupil can ask certain questions via the computer. The computer can give an answer on the basis of the associative relations in the keywords of the question and present a new question. The pupil works through the programme in a continuous dialogue with the computer.

Many of the CAI experts stress the importance of using the

computer as an instruction-sustaining aid for pupils with whom conventional instruction has failed or functioned relatively badly. The pioneer in the sector, Pat Suppes, is conducting a CAI project for the hard of hearing in mathematics and reading (Kanz). In Chicago a start has recently been made on CAI experiments for "educationally disadvantaged children ".

Work is in progress at the Stanford Research Institute on the use of the computer for the mentally retarded. This work is mainly concerned with computer based language training programmes, which it is hoped will establish a dialogue between pupil and computer which in the long run can serve to improve the pupil's language (Waksman).

CAI has been used at Florida State University within "information-sensitive" sectors, e.g. courses in sex education and on drugs. Many pupils feel that the computer gives them a more neutral and less emotional kind of information than is provided by teachers, welfare officers etc. (Merril).

CAI has also been used in teacher training within the handicapped sector, among other things in introductory courses on certain problems, e.g. the diagnosis of handicaps (Moss).

Many researchers feel that CAI cannot be developed any further unless computer-controlled picture screens and, preferably, sound equipment as well, are also included. A text can be presented faster and more plainly with the aid of a CRT screen than via remote writer.

It is conceivable that the reverses suffered in the CAI sector have not been due to any inherent weakness in the actual concept of computer-communicated instruction. The mistakes which have occurred may have been due to a premature practical implementation of CAI and a failure to integrate the programmes with other aspects of teaching. There are indications that computer-assisted instruction will once again become a factor to be reckoned with once schools have access, among other things, to a relatively inexpensive computer with a CRT screen (Waksman).

<u>The computer applied to information, documentation and research</u>

One example of an information and documentation system is ERIC (Educational Resources Information Center), which has developed from a pure information system into an information analysis system. In practice this means that specialists read journals, books etc. in a particular sector, synthesize the information contained in them, assess them in the light of their experience of the sector and analyse them. The reader wishing to consult the source can identify it with the aid of the computer. The summary can also be presented via microfilm, microfiche or photostat copies (hardcopy) (Tresher).

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The TIES project (Total Information for Educational Systems) in St. Paul, Minnesota, comprises information systems including among other things pupil information, merits and tests. The project also includes field research, which among other things involves population projections and curriculum design (Campbell). Another large information system is to be found in Houston, Texas (Hancock).

Computer-based information systems have come in for a certain amount of criticism (Duerstock, Molnar). Often these systems have been constructed to accommodate large quantities of information. But the decisions that have to be taken in a sector do not always require large quantities of information but rather selected information or knowledge. At present it is very difficult for the computer to supply information of this kind.

Summaries of conversations and discussions.

Lack of space has precluded the inclusion of all conversations and discussions in this report.

The summaries are presented in chronological order following the itinerary. 1)

1) Mr Thomas C. Campbell, Mr T S Hancock, and Mr Thomas Byrne were interviewed by Mr Leif Gouiedo. All the other interviews were conducted by Mr Åke Andersson

Dr Roger Myers, Teachers College, Columbia University, New York

The ECES project

Myers has since 1965 been involved in the so-called ECES project (The Education and Career Exploration System), a study and vocational guidance project built up by IBM in collaboration with vocational guidance specialists at Teachers College, Columbia University. The project concerns pupils in grade 10. ECES is to be regarded as an attempt to make the pupil more interested in the whole subject of choosing a career and at the same time to give him a proper chance of obtaining information from different occupational sectors. This information is matched with his aptitude in terms of capacity, interest and achievement. In this way a pupil can rapidly undergo a theoretical "vocational practice" and so increase his ability to choose.

The project comprises three components (blocks). The first of these concerns information about the individual, i.e. in the present case the information collected via the school's administration. This can be said to comprise cognitive tests, namely capacity tests, interest tests and achievement tests. The second component of the system, also based on tests, concerns a self-appraisal test and comprises three parts: capacity, interest and achievement tests. The third component consists of data on occupations and occupational qualifications together with study opportunities and entrance qualifications against which the two preceding components have to be matched. A matrix giving information on minimum study level requirements for study alternatives and occupations has been built into this component on the basis of data collected every two years. The matrix includes a classification schedule of the study routes and occupations of different branches of industry and commerce ranked according to their relative levels.

Efforts are made in the ECES system to activate the pupil so that he can then put meaningful questions to his careers guidance teacher and obtain the help he needs in choosing his future career. ECES gives the pupil an opportunity to define a narrower range of interest groups and spheres of interest in which he is capable of working in the future. In this way he can devote more time to the search process within these groups and spheres.

The vocational guidance teacher plays a more limited part in this system than in a system where he has to collect and supply information on occupational qualifications etc. As things are today he cannot perform a fraction of the duties incumbent on him. The ECES system relieves him of routine tasks, enabling him to spend his time on more important matters such as counselling concerning studies, financing etc.

So far the ECES project has developed in three stages:

1 Development of a working plan for the system

2 Development of a data bank and procedures for the utilization of the system

3 Testing of the system on a suitable group, which has so far been done in Flint, Michigan.

Each of the schools taking part in the experiment has its own terminal equipment. The equipment includes a light pen and CRT screen. The students work (generally in groups) with the terminals at fixed times, with older and more experienced students helping their younger and less experienced fellows. The whole exercise is supervised by an adult who is familiar with the system and the terminal equipment. The students are given code books together with processing batches displayed on wall charts. The cost of four terminals equals the annual salary of a single vocational counsellor.

The systems component containing occupational data may be revised alternate years, this being the interval at which the official source publications used are issued. For obvious reasons, those parts of the component which have to do with

a) study paths offered by different seats of learning

b) courses of studies offered

c) the costs entailed by the pursuit of these studies cannot be up-dated very often.

The future of the project is somewhat doubtful, but it will probably continue for a further two years. New experiments are being made in 1971/72 with grade 10 in Flint, Michigan. Also the pupils included in last year's experiment and now going on to grade 11 will be followed up.

Dr James Moss,US Office of Education,Washington

Dr Moss administers a number of development projects which include the use of the computer for different purposes or for different pupil categories such as the hard of hearing and the mentally retarded.

1 Computer-assisted instruction for the hard of hearing

A project concerning the use of the computer for the hard of hearing, among others, has now been in progress for about a year. The reading and mathematics material previously compiled by Pat Suppes of Stanford University has been modified for partially hearing pupils. This experiment is headed by Pat Suppes.

2 The computer used for information retrieval

One such project is Computer Based Resources Unit (CBRU), i.e. a system whereby a teacher feeds a computer with the problems concerning one particular handicapped child. In return he then receives a "resource unit", i.e. instructions as to what aids, books, diagnostic tests and suchlike are to be used for that particular child and its problems. CBRU is a species of CMI project. Another project is CBIS (computer-based information system). CBIS is an attempt to chart experimental and research projects in the handicap sector, i.e. an information and documentation system of the same type as ERIC but specialising in handicapps.

3 The computer in teacher training

Computer programmes have been used to provide ordinary teachers with introductory programmes concerning different problems in the handicap sector. There are also computer-based courses for remedial teachers in the handicap sector.

On the whole Dr Moss is fairly optimistic concerning the possibilities of utilizing the computer in the handicap sector, particularly in the context of teacher training.

Dr Andrew Molnar, National Science Foundation (NSF), Washington

The tasks of the National Science Foundation are to support basic research, above all in the field of higher education, and to support curricular work in both higher and lower technical education, secondary schools included. The NSF is supporting over fifteen projects connected with computers in higher education. Molnar points to five sectors as being of primary interest:

1 The Illinois experiment

A computer experiment primarily concerned with CAI is in progress in the state of Illinois. This involves 2000 terminals with graphical reproduction. Use is being made among other things of a plasma CRT creen (designed by Professor Don Bitzer) and a limited range of sound equipment.

2 The Texas experiment

This includes mini computers with picture and sound equipment. The idea is to build up equipment which can be augmented as the need arises. One of the important aims of the experiment is to bring down computer costs to about 30 cents per student hour. Costs are estimated to be about 35 dollars per pupil p.a. and they are falling rapidly, particularly as regards technical equipment. The main obstacles are in the software and curricular sectors.

3 Regional data networks

In the hope of arriving at a better distribution of computer resources and experience, an attempt is being made to get certain universities to co-operate in 23 regional data networks. Many different activities are being performed: the computer as a calculator, CAI, CMI etc. But the various areas of application are easy to merge.

4 Use of mini computers

It is possible today for between 5 000 and 60 000 dollars to obtain a mini computer with 10-15 terminals having a data capacity which was formerly restricted to large computers. Certain institutions use this equipment for laboratory experiments. Others make the small computer serve the large one, using the two interactively. Smaller computers are becoming increasingly common in institutions.

Rapid developments are to be expected. Mini computers are being built up into systems and used either as separate computers or as terminals in a system.

5 Computer-based information systems

Molnar was critical of computer-based information system. These information systems are generally designed to accommodate large quantities of information, but the problem is that the

decision which have to be taken in a sector do not always require large quantities of information but rather, and above all, selected information (knowledge). At present the computer is not particularly good at this kind of selection.

Question: How would you describe developments in the "computers in education" sector?

Molnar: Costs are falling so rapidly that within the next 5-6 years most educational institutions will have access to computer resources e.g. for purposes of instruction and learning. "The computer as a calculator" is a sector which can be developed rapidly.

CAI is potentially capable of reducing education costs considerably during the next 5-10 years. A place should be found for full-scale comprehensive systems within that period. The greatest obstacle to rapid development is comprehensive curriculum development.

When one considers that within the next few years 50 per cent of the USA's GNP will be based on computer-managed activities, the need for universities and schools to make use of computer resources is not particularly difficult to understand.

Dr Richard B. Otte, Research Associate, US Office of Education, Washington

A group at MITRE, a firm originally set up by a number of M.I.T. researchers, has developed a prototype data configuration consisting of terminals with among other things an ordinary TV receiver. Commercial cable TV is used to convey signals to the receiver units. A video tape recorder serves as a module selector between the TV set and the cable connection. The terminal is also equipped with a response device and a typewriter.

The memory unit is so limited that it can only retain two frames at a time. The system makes use of reserve channels for commercial cable TV, which helps to bring down costs.

This prototype is now undergoing evaluation. The computer equipment costs are probably the lowest in the country. The purchase price of this unit for 128 users (terminals) will be in the region of 400 dollars p.a. (the overheads are spread out over a period of 8 years). To this must be added running and maintenance costs together with software costs. This computer equipment raises completely new possibilities for the development and realization of CAI instruction.

The Texas experiment

A project has just started in Waco, Texas, for the use of "semi-intelligent terminals on a nation-wide basis to look into a national educational computer utility". The project is being led by the Western Institute for Science and Technology, Waco, Texas.

The computer system is based on a large central computer to which terminals can be connected for batch processing. This means that the system can be used by pupils for various educational purposes and by schools for administrative activities.

The first phase of the project entails connecting schools in different parts of the country. The terminals are of the "semi-intelligent batch type", i.e. in addition to a large central computer there is a mini-computer, a writer, a card reader, a CRT screen and some kind of in-feeding member.

The mini-computer is of size PDP-8 .The aim of the mini-computer is to make it possible for certain computer activities to be conducted at local level and at the same time provide in-feed and out-feed/input and output members for a large central computer in Texas.

Question: By what stages is the experiment proceeding?

Otte: First we are connecting up 5 remote terminals. After two years we will probably have 30-40 terminals working, after three years 60 or more. The local school, college or university pays for its share of the equipment. By the end of the third year we hope that the experiment will be paying for itself as far as the equipment is concerned, in which case we will discontinue Federal aid.

Question: What particular questions do you hope this project will supply the answers to?

Otte: First and foremost the question: is it economically feasible at the present stage to set up a computer network covering the entire country? We hope to find out what problems arise when data networks cross state boundaries, something which can lead to political problems as well as problems of distance. We also hope to find out to what extent a system of this kind can support both administrative and purely educational aims. We expect that a comprehensive data system will prove cheaper than a system in which every school has its own computer.

Dr Ward Mason, US Office of Education, Washington

Dr Mason is in charge of "Regional Labs" and "Research and Development Centers", both of which are concerned with research and development work. There are 25 such institutions altogether in different parts of the USA.

There are a number of programmes involving computers:

1 Southwest Regional Laboratory in Los Angeles is conducting a CMI experiment in which efforts are also being made to employ the computer as a research instrument.

2 The Learning Research and Development Center in Pittsburgh, Dr Robert Glaser, is engaged in research on CMI and CAI.

3 Research on better schools is the title of a partially computer-based experiment in progress at Philadelphia.

4 The Northwest Regional Laboratory in Portland, Oregon is developing the so-called REACT programme for the application of computer technology.

5 The Regional Lab in North Carolina is working on the application of computers to administrative tasks.

6 The Wiche Project (WICHE: Western Interstate Commission for Higher Education), which has now been in progress for several years, is aimed at the development of a "standard data system for colleges and universities to use for management purposes", in other words a computer-managed management information system.

Professor Wilbert A. Pinkerton, Jr., Harvard University, Graduate School of Business Administration, Boston

Pinkerton has tried to use the computer for management games of various kinds and as a means of achieving interactive learning.

Pinkerton:

The computer is a necessary aid in management games in teaching. This need not entail the realistic reproduction or simulation of a particular activity. It can be enough to programme the decision data needed by the different teams (who compete against each other) for each new move confronting them. Computer-based simulation models can also be used to give students an insight into the situations which can confront a manager. At the same time the student can learn how to utilize computer-based simulation so as to obtain more reliable results.

The students find this form of teaching extremely useful and efficient. Two hours after they have made a particular decision, e.g. on a question of marketing affecting sales during the third quarter of the year, the results are in their hands and they can go on, four or five hours later, to consider decisions concerning the fourth quarter.

Game programmes of this kind can now be bought at moderate prices. For 12 dollars one can get a manual, student material and the programme (on tape).

Dr Zenon S. Zannetos, Massachusetts Institute of Technology (M.I.T.), Boston

Zannetos:

I have been working on programmed instruction for many years. I soon became convinced that programmed material should not be "offered" via a teaching machine but should instead be presented in the form of a programmed text. Programmed text is cheaper to reproduce in book or booklet form and it takes less time (no waiting time).

For a long time people thought that computers should be used in the same way as teaching machines in programmed instruction. This is feasible but it is an expensive procedure. There are undoubtedly more sophisticated applications available for the computer as a teaching aid.

In my opinion, the sector where the computer really comes into its own is concept learning and the study of relations between concepts (conceptual structure). The experiments we are conducting and which we have been working on for three years are called the Associative Learning Project. For instance a student should be able, via the computer, to ask: What is the relation between concept A and concept B? Via the computer the student can obtain definitions, be given an opportunity to structuralize relations and obtain an answer to his question. The experiment is primarily related to accounting (book-keeping) studies.

This argument presupposes that information is not just data but a combination of contextual association in data context. In fact we cannot deduce information from data unless the data are placed in the right associative context. It follows that a student would learn more if we could show him how data are used in a context.

To begin with we tried to offer the material to students in the form of programmed teaching material (text). Next we tested CAI material of a normal type. Finally we arrived at the idea of using a combination of methods making better allowance for the complexity of the subject matter and the desires and knowledge of the students.

In the experiments we are running at M.I.T. we first let the pupil work through a computer-based programme which is designed in such a way that each individual step offers him a choice of routes to the next step. For instance, he can ask a question connected with one of the steps he has already passed. The computer will then take him back, say, to a certain definition and structuralize certain relations. In this way we hope that the student, starting on the basis of his own limited knowledge,

will be able to derive greater insight by his own unaided efforts.

Whereas Skinner's programmed instruction is based on the building up of stimulus-respons behaviour with the aid of predictable responses, our experiment is designed to encourage the student to associate and logically deduce the consequences of the knowledge he has just acquired. What happens is that the student sits down at the computer and asks certain questions. The computer programme can present a question on the basis of the associative relations between the keywords in the questions put by the student. The student works through the programme in a constant dialogue with the computer.

Professor Michael Scott-Morton, Massachusetts Institute of Technology (M.I.T.). Alfred P. Sloan School of Management, Boston

Scott-Morton

Some years ago the Carnegie Commission sponsored a study entitled "The Future of Higher Education". M.I.T. was given the task of writing about the influence of technology on higher education. In this connection we went on a study trip round the USA and found (as I dare say you have also done), firstly, that those educationalists who had been early to implement the computer for teaching purposes had done so in a very traditional way. Often they used a textbook or a programme produced on programmed instruction lines constitute the input in the computer. Now this is a highly inefficient way of using a computer.

The second thing we found was that there was no real basic research being done into the integration of technology, materials and student. Most people were working within a single sector. Those who were working on CAI believed that CAI was the answer to the question how computers should be used. Others who were working on simulation answered: use computer-based simulation models in your teaching and all your problems will be solved. Most educationalists used the computer in a single sector and this tendency is still very much alive today. I only know of two projects where researchers are consciously using the computer for several purposes. In other words, people have forgotten that each sector has its own special requirements. All over the USA there is a wealth of activity connected with the use of computers in teaching. We are spending 70 million dollars a year and most of it is money down the drain.

The report of the Carnegie Commission distinguishes between 1) computers in teaching, 2) computers in administration, 3) non-computer-based techniques (e.g. cable TV, CCTV, microfiche, microfilm).

There are two powerful technological forces influencing the role of the computer in education. One of these is the declining cost particularly of hardware. The other is the development of data networks and good communications between data systems. This will enable us to deliver "intelligent" data power very cheaply to remote installations.

A data network comprising a large or medium-sized computer together with what are known as mini-computers makes it possible to distribute resources in terms of computer bases, programmes and data power.

Question:

What is your view on the development of mini-computers?

Scott-Morton:

The rapid development of mini-computers has taken everybody by surprise. But there are few people who make intelligent use of mini-computers in teaching. Some mini-computers today have the same capacity as yesterday's medium-sized computers. For instance a Super Nova from the General Data Corporation has approximately the same data capacity as the IBM 360/30 used to have. It costs no more than 45 000 dollars. Costs are falling by 60 per cent every year.

If anybody had asked me only a year ago what such a data resource would cost, I would have said 400 - 500 000 dollars. Technically knowledgeable friends of mine say that the price can still be reduced nine times over, which means that this data resource can soon be had for 5 000 dollars. This computer is incredibly reliable. One can perfectly well use the equipment which is being used in the open market and which is now getting progressively cheaper. The experiments being made for instance at the University of Illinois to develop a specially cheap picture reproduction terminal are therefore in my view of little interest. The hardware developed by the open market is getting so cheap and so useful that we do not need any special equipment for educational purposes. Hardware is unlikely to present any problems where prices are concerned. Probably the decisive factors will be the teacher's time, programme production and suchlike. The problem is to produce material in a form which makes it worth using in a machine. A close knowledge of the curriculum is also important if you are to know what bits should be programmed for the computer. The bottle neck then is connected with pedagogically serving the material in such a way as to make it meaningful to the student.

Quite a lot still remains to be done where terminals are concerned. I do not feel that we should start developing specially designed terminals for the educational system. Costs are falling rapidly. A terminal which cost 15 000 dollars two years ago only costs 2 000 dollars today. What schools need is picture reproduction with light pens or touch-sensitive screens.

Question

How do you feel about CMI?

Scott-Morton:

CMI presupposes a knowledge of the components of the learning and teaching processes, knowledge which we do not actually possess. CMI assumes that the computer can predict the next step or stage to be taken by the student. There are perhaps 20 possible so-called next steps. Using the computer to predict for the student what is going to happen next is a waste of the student's time and of computer power. It is a waste because

the task is far too destructuralized. We do not know enough about the premises to be able to use the computer in this way.

Now it would appear that most CMI projects in the USA comprise efforts to register the student's achievement, something which in my opinion has no connection with CMI at all. It is simply computer recorded instruction. My impression of the CMI projects in progress in this country is that the project leaders do not really know what they are doing. As far as the possibility of predicting the student's next step is concerned, that I feel is something which teachers and students can decide far better between themselves.

My personal impression is that we should join forces and above all experiment with the computer in several fields of application. This applies first and foremost to organized experiments in higher education. As far as I can see experiments with people who are just learning to read (and there have been experiments of this kind in many parts of the USA) are a complete waste of money.

Dr. Edwin Taylor, Massachusetts Institute of Technology (M.I.T.), Boston

Dr. Taylor, who is engaged in research into educational problems, described four experiments with computers. Of these four he regards two as failures and two as successes.

Taylor:

1 We tried using very advanced computer equipment to let the student converse with the computer in English by means of a typewriter. The programme was of the tutorial type, which means that the computer "taught" the student, which is difficult and expensive but can be done. We constructed one programme in physics (the theory of relativity) which worked quite well. The biggest advantage was that next morning you had a written report on the student's achievement. This enabled us to see any errors and deficiencies in the programme, which was a great help. This I think was the main advantage of the method. It was an interesting programme but expensive to use. Each student hour cost 14 dollars to run. By financial reasons it was impossible to use.

2 Another experiment was made with a CRT system and several computers.

There are certain fields in physics, such as nuclear physics and the theory of relativity, where it is hard to inculcate insight in the student in a short space of time by means of experiments. Now there are well-defined laws of physics which can be transformed into models with the aid of the computer. The computer can draw a picture of the process to make it intelligible. We developed several CRT screens enabling the

student to sit and point with his light pen so as to change the constants in the model. All this was fun for the student, it worked and it can be seen as an educational success. Unfortunately the computer equipment cost about 150 000 dollars, which would be more than almost any institution could afford.

3 One of our successful experiments is concerned with the use of the computer as a calculator etc.

Students find it very stimulating to use the computer themselves for different calculations. The computer enables the student to do his exercises and solve problems with a richness that cannot be achieved by doing the same things manually. The student gains experience and is able to change certain problems and find out quickly what the results will be. But the really important thing is that the student has to tell the computer how to do things. In other words, the student acts as teacher to a very patient but stupid pupil (the computer). After all, the proverbial way of learning something thoroughly is to try and teach it to somebody else. Docendo discimus. The teacher (student) sees immediately how well or how badly he is teaching and whether the pupil (the computer) can really set up a problem and work out a certain solution. The computer as a calculator is used on many courses with the good effects I have described.

4 The second successful project concerns what we call computer-generated films, i.e. making films with the aid of a computer. We have made a whole series of films. Most of them are about physics (relativity, quantum physics, electricity, magnetism) and are based on pictorial reproduction on the CRT screen. These films can be regarded as a demonstration of a process based on computer-managed calculations. The student can sit by himself and watch these films by way of introduction to a field of study. They take the form of film loops. Anybody can run the film (in the computer programme). Of course you lose the interaction between student and computer, but everybody can experience, for instance, how the difficult concept of relativity is given concrete form in a mobile process.

Taylor's conclusion:

On the whole I am not particularly optimistic concerning the possibilities of using the computer for teaching purposes in the near future. I was more optimistic before. The computer is overrated as far as education today is concerned, but it is underrated as regards the education of tomorrow. We will have to spend a lot of money keeping track of what is happening in this sector. During the last few years, masses of stereotyped programmed teaching material has been stuffed into the computer and this has given a very large number of educationalists a pessimistic view of the possibilities of developing the computer. But we should not forget that there have been a lot of successful experiments, too.

Professor Karl Zinn, University of Michigan and Dr Wayne K. Davies, Research Scientist, Ann Arbor

The EXTEND project

Zinn:

In the EXTEND project we are trying to put the data resources and experience available at the University of Michigan at the disposal of other schools outside the actual campus. This mainly concerns software and literature, but we also want to tell other teachers in the campus how to use the programmes.

The Extend project began in April 1971 and is a two-year project. There are at present 4 schools involved and we are now working to see what schools can use the programmes. We are trying to evolve criteria on this. The programmes are designed to use the computer as an aid to teaching/learning and this involves simulation activities as well as calculations. For instance, we use the computer in economics subjects to simulate "Government Economy" where the programme can be used as an element in a course of economics. This way there is no need for the teacher to go into taxation, tax assessment and suchlike, they can simply be left to the computer. Another sector is statistics, where the student himself can run certain programmes and in a more inductive way learn to understand laws of statistics. A third sector is the testing of hypotheses. Among other things we have access to a large data base from the last Presidential. For instance, students can ask what social and occupational categories and so on voted for Nixon, Humphrey and other presidential candidates. They can find out, say, whether a particular socio-economic group voted for Nixon. From these data, then, they can draw certain general conclusions. In social science the students can ask questions based on these facts via the computer.

Question:

Does CAI have a greater development potential than CMI ?

Davies:

It is hard to compare these two activities, among other things because it is easy to put the wrong labels on them. I do not know if I have seen a single really good example of a CAI programme. As far as CMI is concerned, we have not made any experiments here at the University of Michigan, but personally I feel it is a more intelligent way of using the computer than CAI. But the inportant thing is to let the students use the ordinary teaching material with the computer serving as a kind of accountant-cum-counsellor.

Zinn:

Avoid distinguishing between CAI and CMI. Instead look for activities and learning targets that are suitable for the computer. Perhaps the most important thing is to use the computer as a tool and to teach computer science so that the students are really prepared for the data activities existing outside school. We should not underestimate the ingenuity shown by both teachers and students in using the computer for different purposes.

Dr. Alfred Maley, University of Michigan, Ann Arbor

At the School of Natural Resources where Dr Maley works, experiments are being conducted with computer-based simulation models in biology and other subjects. In an ordinary classroom situation the student is presented with a model showing how a biological "resource" works and how one should learn to understand and handle it. Formerly this was a rather academic task which it was extremely difficult to carry out owing to the abundance of variables. It has not been enough merely to study the theory behind the "resource". Using the computer/computer terminal/time-sharing techniques it is possible to develop simulation models for a natural resource of this kind. If the student makes mistakes in his study of the natural resource, he will of course not destroy anything. This means that he can learn to analyse the way to handle such a resource and also that he can ascertain the relevant variable values involved. He can also learn to analyse material statistically and how to tackle problems in the sector.

Maley gave an account of five different kinds of simulation games. These form part of the classroom instruction. In the classroom the student studies theory. At the computer he learns to "master" the resource. Two or more students play together or against each other.

Question: Is computer-based simulation expensive ?

Maley:

No, not usually. There are two kinds of costs, computer terminal costs and the costs of running the actual programme. The latter amounts to about 3-6 dollars per hour. The cost of renting hardware brings this up to between 6-10 dollars per hour. The third cost, namely the development of the programme, is also a large item. The Natural Science Foundation is supporting these experiments and pays part of the costs. We hope that these programmes will then be used by other universities so that the cost per programme and student will be far less than it is now with only our institution using the programmes. But our feeling is that you have to have games of this kind to be able to teach these matters realistically.

This way too you achieve a much higher degree of student motivation which is probably not just due to the novelty of the thing.

Question: Are all university teachers interested in computer-based simulation games?

Maley:

We have not tried to push anybody into taking part in these activities, but as a rule it is not difficult to persuade people to take part in computer-based simulation.

About 20 per cent of the teachers use these games. We have not progressed very far and we have very few programmes, which makes 20 per cent quite a good figure. We have only been going for a year, so that it is hard to say for sure what the attitude is among teachers and students.

Question: There are many activities known as simulation. How would you yourself define the term?

Maley:

Simulation is above all a method of learning to predict what will happen. When we develop a game we are of course bound to simplify the game in relation to reality, but we must not oversimplify. But the main object of our games is to teach students certain concepts.

Question: How many games have you developed?

Maley:

Five. The first was something we called Simple Salmon in which we tried to teach students the principles of Salmon Reproductive Biology. Another game was about trout. A third one was about forests as a natural resource. This is a game we developed in collaboration with the State Department. The fourth one was about deer in Michigan. Deer management is a political question here in Michigan. We have a feeling that the political optimum concerning deer is not in accordance with the biological optimum. The fifth game was about dam construction in Zambia. The most important questions are: How will the extension of the dam affect the surroundings in terms of fishing resources, impact on natural life and so on? We also have a number of other programmes in preparation. All the students need for the simplest games is a pencil and paper, but the more complex ones require mathematical models and access to computer power. The game about dam construction in Africa is one example of a complicated game.

Normally a student will play against the computer and seldom together with or against another student. If students are to play in pairs the programme must not contain too much material, instead the students must be able to supply the computer with

certain data. As far as games about biological resources are concerned, it is probably advisable for the models to be programmed into the computer.

Question: What are the main advantages of using the computer for simulation?

Maley:

In the first place you cannot simulate a biological resource in or from the classroom and acquire experience of the way to handle it. For practical reasons it is often impossible to do any concrete work with or in the resource itself. Secondly students seem to be more motivated for learning via computer. A third advantage is that the student can play this game when he wants to - day or night - without any teacher having to be present. Many students can play different games simultaneously if you have a terminal and a larger computer.

Dr. LeVerne S. Collet, University of Michigan, Ann Arbor

Dr. LeVerne S. Collet is in charge of a project designed to evaluate "educational programs", i.e. goals, methods and organization for a particular school, school system or school district. Efforts are being made with the aid of computer-based simulation models to investigate and, if possible, predict, the value of a particular form of instruction.

Dr. LeVerne S. Collet: In our project we give our project leaders the task of simulating out the most suitable methods, paths, alternatives for solving a particular problem in relation, among other things, to a particular budget. At the moment we are investigating the value of a series of CAI programmes in mathematics for junior high school. In doing so we have tried to computer-programme into our model the forces acting in the relevant situation. We have also tried to include the forces which can suddenly change the normal working situation of the school or school system.

We are thus trying with the aid of computer-based simulation models to teach experts to evaluate educational programmes, school forms and school systems. We are trying to include all the relevant variables. Normally evaluation in the school-sector takes an unconscionably long time and the evaluation results finally obtained are often irrelevant in view of the developments that have taken place since evaluation began. Besides it takes such a long time to train evaluation experts that the knowledge they obtain tends to be out of date.

But one of the prerequisites of good simulation is for the data we put into the programme to be representative of the situation at large. This is a major problem in itself. We cannot include more than a hundred or so variables in the model.

The computer used as a simulation aid gives immediate feedback, which is of great importance. The computer enables us to handle a large number of highly complex relationships.

The aim of computer-based simulation, then, is to give students in a laboratory situation the experience they would acquire if they were working outside and at the same time to give them the feedback showing how well or how badly the model fits into the school situation.

Question: What are the greatest difficulties in this sector?

Collet:

Above all getting the computer programme to give the answers we want. Another problem is to know on what grounds to decide whether a model or parts of a model really give an accurate picture of reality. To solve this we are trying to match statements and verdicts from experts in the school sector with the data we obtain.

Mr. Henry Strassburg, Assistant Superintendent, Chicago Board of Education, Chicago

Strassburg is head of the Department of System Analysis and Data Processing, which is divided into six separate bureaux.

One of these is the Bureau of Computer Based Instructional Systems, which falls into three sections:

1 Computer Education
2 In-Service Education
3 Computer Assisted Instruction

The bureau is responsible for all teaching with computers and about computers. Computer education is supplied to 71 high schools. Each school has one or more IBM 360/50 (full-time). The course in data processing techniques which is given constitutes a special subject and is studied for four years. It comprises: fundamental concepts of computer techniques together with one programming language. Three periods of the five physics practicals every week are devoted to training the students in computer techniques which are directly applicable in physics experiments. In other words, the students learn to solve physics problems with the aid of the computer.

Economics students learn how to compile a register and how to compile an inventory system. This instruction makes it easier to place the students in the labour market.

Strassburg: We take care of all the school management's administrative work: salary routines, accounting, personnel etc. We have all the personal particulars on data (on-line, realtime-basis) (900 complete character records). This data bank

includes both teachers (on-line) and students. Whenever a student moves we are told about it, i.e. what school he is attending, what school he has been attending, which classroom, his address, telephone number, test scores. On the other hand we do not have absence/attendence on data. We tried, but the practical difficulties proved too much for us. The system never worked.

We have been working for 4-5 years on timetable construction with the aid of computers and we have had great success. All these 71 high schools have their timetables planned by computer and we have got up to 99.4 per cent right when it comes to putting students in the right groups. Perhaps the main secret of our success is that the system work has been done by a former teacher whom we have taught computer techniques. This man works full-time at computerized timetable construction. Computerized timetable construction no longer poses any problems for us. We do it purely as a matter of routine and we makes a go of it every year.

The data system does not yet include school buildings, equipment of teaching materials, but we are going to make a start on teaching materials. Next year we will be embarking on a field study in the schools concerning methods for keeping records. Our greatest problem is the volume - the numbers of teachers and students are so high.

Sooner or later we will have to instal an administrative terminal in every school, where data can be collected and forwarded.

We have not yet used the computer for study guidance, but we may/will eventually penetrate this sector.

Question:

How do you view the teacher's role in a computer-based school administration system?

Strassburg:

Teachers cannot expect to derive all that much help with school administrative data from a computer during the first 4-5 years. It is hard to measure the value of the teacher having access to certain data from a computer. In most parts of the USA they have postponed putting teachers onto a computer system.

As far as the problem of the structure of the data base is concerned, I do not really know what the data can give the teacher in the form of school administrative data that the teacher does not know already. Perhaps there is no point in giving the teacher the student's test scores via a computer, for he already knows them anyway. And of course he also knows that the student was absent. Of course, student data can be registered, but one should bear in mind that these data still

have to be obtained from the teacher, for it is the teacher who feeds them in. The same goes for placing the students in grades. This, too, is something that comes from the teacher. Besides we should remember that not everybody supplies correct data, which means that a complicated procedure has to be developed to avoid these errors.

If you are going to start building up a school administrative system, the simplest way is to start with a teacher register or personnel register for the entire school system, including information on teachers'salaries. Next you should go on to student information, i.e. student data of various kinds, followed by accounting and pay rolls. This chronological order is not the cheapest way of beginning, but it is to my mind the logical way. Then you can go on to include buildings and equipment. Once you have done all this you have a kind of management information system.

But it is very important at the outset to have carefully investigated the surroundings in which the computer is to be placed. I would like to caution people against following the advice of the data processing specialist too implicitly. Of course the systems man is necessary, but he must be constantly matched with people in the school. The best thing is to engage somebody who is both a systems man and a school man. If you cannot find such a person, then the best procedure is to take a teacher and train him in systems analysis, rather than taking a systems analyst and teaching him pedagogics.

The biggest investment, and the one to which we should devote most effort, is to chart the way in which the school works. Decision making authorities often find this hard to understand. And they also have difficulty in understanding that systems work takes a long time.

Question:

In what other sectors have you used the computer as an aid?

Strassburg:

One new sector we have just gone into is computer-assisted instruction. We have just installed a Univac 4183 with 105 CRT terminals distributed between seven schools. We supply the schools with CAI reading courses for grades 3-6, mathematics for grades 1-6, language arts for grades 3-6.

The students taking part are classed as "educationally disadvantaged children". For instance, the pupils taking part in the reading experiment have to be one year below normal achievement level to qualify for these computer-based courses. The CAI courses are mainly intended for students needing auxiliary teaching which may bring them up to the normal level.

We operate on the drill-and-practice principle. It is the job of the teacher in the classroom to present and introduce concepts. Their daily sessions are confined to 10 minutes a day, i.e. the student can have 10 minutes' reading and 10 minutes' mathematics.

One interesting thing in this experiment is that it makes use of teacher assistants, including unemployed persons with no special training who have been brought in to help the students with certain practical matters.

The CAI experiments we are now engaged on are above all designed for handicapped children and children coming from difficult social environments. At present it costs 800 dollars a year to provide instruction for one single pupil in this category, and we get very little in return for those 800 dollars. We cannot teach them to read and write with present-day methods. Consequently there is no reason to compare the cost of CAI with a form of teaching which does not have any results. We are simply forced to resort to unconventional teaching aids such as computers if students are to have any possibility at all of making progress. It follows that any discussion of "cost/effectiveness" is completely irrelevant here.

Children above the normal stage or above the normal achievement level have not shown significantly greater progress in tests. Children below the normal level on the other hand have exhibited significant differences compared to a control group. This applies to the drill-and-practice method using CAI.

We intend to carry out three separate CAI experiments:

1 Drill and practice
2 The tutorial mode
3 Don Bitzer's project

We will also be testing Don Bitzer's terminals, known as plasma terminals. For the drill and practice method we are using Univac, which can serve 480 terminals and 32 schools. In the second experiment (the tutorial mode) we will be operating IBM system, possibly in 3 high schools. In the third experiment we are going to try out Don Bitzer's plasma system with different computer configurations. We will have between 25-30 plasma terminals in each school.

We are still more uncertain as to what we ought to concentrate on most. There are today so many technical innovations and so many different methods that it is impossible to decide in favour of a particular solution. On the other hand we do not want to wait too long: we want to be in on things from the start so that we can build up a fund of know-how. If we now bank on three different ways it will not matter very much if one of them proves unsuccessful. We are fairly certain of the success of two ways, namely drill and practice and tutorial mode.

I am absolutely convinced that during the next 5-10 years the computer will come to be widely used for computer-assisted instruction, especially in junior school and high school. Look at the results obtained at Stanford University with computer-assisted instruction in Russian. They show that there are things which the computer can do better than any teacher. Computer-assisted instruction has made enormous progress during the last five years at college level and in the armed forces. IBM have 600 terminals in Poughkeepsie to teach their engineers certain fundamental concepts of in-service training. The US army, navy and air force have found CAI to be a highly efficient aid.

The teachers now taking part in our CAI experiments have not been taught anything about computer techniques but have been given a brief introduction to the experiment. The teachers are tremendously enthusiastic about CAI.

Question:

What are your views on teletype vs. CRT screen?

Strassburg:

A student using teletype can get through three times as much subject matter as with conventional teaching methods. During a ten-minute period with a CRT screen a student can get through what normally takes 50 minutes with ordinary teaching methods. Teletype is cheap (595 dollars) but noisy. CRT is four times as expensive but it is fast and quiet. If you use teletype for division, you cannot reverse, that is to say you cannot go back and insert the dividend or whatever it may be. Teletype is slow in relation to CRT, 10 signs per second.

Question:

What do you think of mini-computers? Can they be used for CAI?

Strassburg:

Yes, in a small school with up to 600 students. But small computers are quite expensive to maintain.

Question:

How do you feel about the future? What is going to happen in the data sector during the next 5-10 years as far as the educational sector is concerned?

Strassburg:

Every school is going to have a terminal for administrative tasks, run on a time-sharing basis. This terminal will be able to supply the central authority with every conceivable item of information every day and every hour. Paper and pen work will disappear.

At present CAI is being held back by the discussion of cost/effectiveness. The second problem holding it back is the lack of sound equipment.

As far as CMI is concerned, it required a so-called data bank of student data which is very difficult to build up. If CMI is going to be efficient we must get hold of every conceivable item of information about the student, e.g. his socio-economic background, how he reacts emotionally and mentally and so on. These particulars could very easily be fed in and it could help every student to obtain via the computer the questions and material he needed. But for reasons of official secrecy we cannot feed in these data. As far as I know, the Naval Academy is the only establishment in a position to build up a data bank containing full personal particulars. They have programmed in everything they know about each student and CMI works very well there.

Thomas C. Campbell, director, Minnesota School Districts, Data Processing Joint Board, St. Paul, Minnesota

The Minnesota School Districts Data Processing Joint Board was set up by twenty school districts in 1967 to create a unique service for the school system: Total information for Educational Systems, TIES. This is a centralized computer system, half the expenses of which were defrayed out of federal funds during an experimental period lasting until 1969/70, the remaining funds being provided locally.

By 1970 the number of school districts taking part had risen to 29, representing an approximate total of 245 000 pupils in 200 primary and 80 secondary schools. The TIES project har led to the creation of:

- an on-line information system in which use is made of the telecommunications network

- an integrated data base

- advanced systems ware for information systems

TIES is concerned with three functions within the school system: administration, teaching and research. The following examples can be given of applications within these sectors:

a) salary routines (salaries to approximately 30 000 employees every fortnight), which are to be included in a personnel administration information system

b) pupil information systems containing among other things timetable construciion, report production (test results, merits etc.), class listing (approximately 80 000 secondary school pupils)

c) time-sharing systems for teaching purposes: problem solution, marking of tests

d) field research, including population projections, curriculum design (curriculum research projects).

TIES is generally regarded as a good example of an overall system for data processing within the educational sector, unlike the more specialized data applications that are to be found in many quarters.

On the hardware side, TIES has at its disposal two Burroughs B 3 500 computers connected to 34 data input and display terminals (including a Burroughs 9352 CRT) installed in the school districts. There are another 130 "ordinary" teletypes (T 33) and five card readers.

In future TIES is to concentrate on the following three sectors:

1 Computer applications for teaching and curriculum. Experiments are already in progress using graphic plotters, comprehensive achievement monitoring, drill and practice. Special emphasis is to be laid on developing the connection between instructional use and data base.

2 Development of the important research resource constituted by access to an integrated data base.

3 Development of activities for training decision makers at various organizational levels in the school districts to utilize the potential of the computer system.

The following quotation should give a fair indication of the impact of the computer on the educational sector as seen by the project leaders:

"Future impact of the computer on education will be gigantic and is likely to develop much faster than generally acknowledged. New levels of efficiency and economy in education will be made possible via computerized information systems.

Perhaps the greatest impact will be in the management of complex, long-term learning programs for individual students. Much of this learning will occur away from classrooms but will be designed and guided by competent, professional educators working with computer professionals."

Dr. Grace Kanz, Stanford University, Palo Alto

CAI projects

Mrs Kanz is co-ordinator to the schools taking part in the project for the utilization of the computer as a teaching aid

(computer-assisted instruction: CAI). It is her responsibility to see that teachers are informed how to use the computer, help them with such problems as arise, take care of the results of the project and so on. It is also her task to assist the teachers in curriculum work, i.e. suggest suitable items for drill and practice with the aid of the computer.

The subject with which they first began and on which most of their work is being done is mathematics (drill and practice). The course, which covers grades 1-6, comprises basic arithmetical calculation. (A modified form of the same programme is being used e.g. in Chicago, though with different technical equipment). Another subject is initial reading, which now only occurs at one school, Brentwood school, where the pupils have access to a teletype terminal and earphones. A third subject is logic algebra, which is a tutorial course designed for bright eleven-year-olds, though this course continues up to college level.

A fourth programme is language arts. This is specially designed for the deaf and hard of hearing. The reading level is kept down to grades 2-3 in view of the difficulties encountered by the hard of hearing in learning to read.

A fifth programme, entitled Basic English, is a type of auxiliary course comprising a review of and commentary on frequent language errors, punctuation errors etc. for high shool students.

Kanz: We are developing a programme for adults who have not been to high school but need to acquire the corresponding knowledge. Another new programme is for previously convicted Indians who need some kind of general course. We also have computer-based courses in certain programming languages.

CAI activities began in 1965, mainly at Brentwood school, which was chosen because of its location in a socially underdeveloped area. The programmes are also being tested elsewhere in the USA, e.g. in Texas and Washington D.C.

Programmes for the hard of hearing are being tested in several schools in San José, California, and elsewhere.

Question: Which pupil category have you been most successful with where CAI is concerned?

Kanz: It is hard to say. If we consider the children from socially underdeveloped areas, one can see that they have made considerable progress, though to a great extent this is due to their having been given so little instruction that any teaching input is bound to result in great improvements.

For obvious reasons, less progress has been made with ordinary children. CAI programmes in Russian have been most effective. Not only have they resulted in demonstrable differences, the normal drop-out percentage has fallen drastically from 60-65 to practically nil. In a year-long CAI experiment in Russian involving 30 students in the experimental group and 30 in the control group, the experimental students gained significantly better results in the test than the control group students, who after one year's studies only numbered 12, while the experiment group retained 28 of its students.

Question:

Are the CAI courses comprehensive or do they cover lesser units?

Kanz:

We have two kinds of courses. Logical algebra, for instance, is "tutorial", i.e. comprehensive and self-instructional, so that anybody with the time and the inclination can work through it on their own.

The mathematics courses, on the other hand, are drill and practice, which means that the programme drills the student in the exercises which the teacher has alreadey gone over in the classroom. The idea is to relieve the teacher of these exercises, which none of the teachers have time for anyway, owing to the individual differences existing in the class. The computer is assumed to be able to drill better than any teacher who cannot stand over every student and tell him what is right or wrong, why the student was wrong, what he must do to get the calculation right and so on. Nor can the teacher tell each individual exactly which exercises he needs to go through again.

Question:

Then how do you define "tutorial"?

Kanz:

"Tutorial" implies that the CAI programme gives the student everything he needs to know, i.e. apart from the actual subject matter it also provides him with an introduction to and explanations of what he is to learn.

Question:

What do you feel should be the proportion of normal teaching time to the time spent by the student working on a CAI programme?

Kanz:

I do not know. We are not closely enough in touch with the school situation to be able to answer that question. We leave

it to the teachers to decide. In the mathematics programme the student is supposed to have 5-10 minutes drill (via computer) every day. We feel that 10 minutes is the maximum for a single session, for the student has to concentrate so hard and he is given so many more tasks per minute via the computer than in the classroom that he gets tired after 10 minutes (younger pupils are only given 5 minutes). But some teachers give their students two sessions a day, which makes 20 minutes of CAI programmes every day.

In the language arts programme we let the students sit at the computer for as long as they like. There have been cases where they have spent six hours a day at the teletype terminals. On the whole the exercise dosage at the terminals varies according to student category, subject and student interest.

Question:

What are the most obvious advantages of CAI?

Kanz:

1. Greater learning effect, 2. The teacher is relieved of fatiguing drill exercises (which means that he can concentrate on teaching instead of being a drillmaster). 3. CAI increases the students' learning rate. 4. CAI gives much higher motivation that ordinary teaching. Often one finds that problems presented via the computer attract the student more than when they are presented by the teacher. The student feels more compelled to both answer the questions and immerse himself in the problem if it comes via the computer.

The motivation derived by students from the computer is sensationally powerful and it seems to remain unimpaired in students who have been working on CAI programmes for over four years.

Dr. Abraham Waksman and Dr. Sylvan Rubin, Stanford Research Institute (SRI), Palo Alto

Stanford Research Institute (SRI) was founded in 1946 by Stanford University but has always worked as an independent unit. It has been completely separate from the University since 1970.

The firm employs 2 500 persons, of whom 1 400 are researchers within the Institute. Annual budget: approximately 70 million dollars.

The Institute carried out research and development tasks for state, regional and local authorities and for private enterprise in the USA and elsewhere. The main sectors covered are natural sciences, electronics, management systems and urban and social systems.

Experiments with computer-assisted instruction (CAI)

Dr. Waksman is working on the use of the computer for the mentally retarded. Efforts here are being concentrated on language development, which is regarded as a key sector where the mentally retarded are concerned. Work has already been done with partially hearing pupils and the plan now is to make use of some of the CAI programmes produced in that connection. It is hoped that work with computer-based language training programmes for the mentally retarded will bring about a dialogue between pupil and computer which in the long run can serve to improve the pupil's language. In the eyes of a mentally retarded pupil, the computer is a neutral object which does not in any way seem challenging, as the teacher or teaching material can do sometimes. The teaching material is at times too impenetrable and can therefore be interpreted as a threat to the pupil's self-confidence.

Thus it is hoped that the pupil's own manipulation of the computer will have positive results. These results may entail no more than his answering yes or no or perhaps sometimes in his supplying a short answer to a particular question. It is expected that the interaction developing between the pupil and the neutral computer will be carried over to the pupil's work in the classroom together with the teacher and in his relations to other adults with whom he has to co-operate. It is hoped that certain indicators in the programmes and in the testing technique will promptly reveal the advantages or potentialities of the teaching method. Presumably the indicators can be modified to yield increasingly better results.

As in the previous experiment with partially hearing children, it is envisaged that the computer programmes for the mentally retarded pupils will be composed by the teachers themselves. The programmes which have been made are a species of explanatory programmes or, as they are also termed, "free-flow programs". What happens is that one asks a question and hopes for an answer from the pupil. It is assumed that the pupil has answered, and new information is supplied on the basis of that answer together with a new question. The idea is to avoid rigid programmes with clear-cut questions and answers and instead establish a dialogue between computer and pupil with the aid of flexible programmes.

At present computer-based instruction costs 5 dollars per hour. This cost is not regarded as a real obstacle. The computer need not be used for more than limited portions of the course/ subject.

The utilization of the computer in teaching does not imply that the teacher is relieved of certain tasks. Experience has shown that his work increases when there is a computer available for use by the pupils (and teachers).

Asked why computer-assisted instruction had not lived up to expectations, the interviewees replied that, to begin with, the programmes were of a purely experimental nature but were nonetheless made far too rigid. Nor was there a good integration of the teacher's activities in the classroom and the pupil's activities at the computer. Often the programmes did not follow up what the teacher had worked on in the classroom. Sometimes the pupils were given programmes to work on which were irrelevant to the subject in hand.

The reverses experienced in the CAI sector are probably not due to any inherent weakness in the actual concept of computer-assisted instruction. The mistakes that have been made are more to be seen as the result of neglecting to integrate the programmes with the rest of teaching.

As far as technical development was concerned, the people at SRI thought that it would be wise to bank on medium-sized computers and mini-computers placed at a central point in a local school system. The computer equipment ought to be capable of serving about 30 terminals. Possibly one might make do with a computer which can only serve 16 terminals. This arrangement is quite an attractive one from the economic point of view. An installation of this kind can take care of a fairly large data base and still serve terminals. Assuming a five-years utilization of the installation, the cost per pupil would not exceed 1 dollar per hour.

This configuration of data power may be the type adopted by many school districts in the USA. The same equipment can also be used for purposes of school administration, thus bringing down the cost per pupil still further. One such system has been in use on a trial basis for some time in Palo Alto. There are also instances where separate computers are needed for instruction and school administration respectively.

There is a lack of software for motion pictures. According to Rubin there are no standardized programmes for the combination of sound and picture. A programme for one display unit will not suit another. As far as developments in the picture sector are concerned, the epithet chaotic would not be out of place. If the picture problem is solved (in purely financial terms), the information retrieval potentialities will be enormous. One possible solution on the picture side lies in the combination of computers and TV, with TV taking care of the pictures and of interaction with the computer.

Dr. David V. Tiedeman, American Institutes for Research, Palo Alto

Tiedeman has been leader of the study and vocational guidance project ISVD (The information System for Vocational Decisions) at Harvard University.

The object of the ISVD system is for the student himself via different forms of search processes to arrive at suitable study and occupational sectors. The careers teacher then helps him to find out which sector suits him best. The data bases contain a host of data about the student. These may include personal data, test data within a particular educational sector and so on, and can be matched with vocational decision data.

The student's personal interest in his vocational decision is an important factor in ISVD. The system presupposes that the student will become so interested in vocational guidance as to make active use of the guidance opportunities presented by the computer, e.g. the capacity of the computer for identifying and classifying data and making them available at the right moment.

The ISVD is constructed in such a way as to enable the student to match his own knowledge, interests and attitudes with information data about education and work and so acquire the information on the basis of which he can come to a decision in the matter of choosing a career.

The whole ISVD programme links together student, computer and careers teacher. The student can conduct a dialogue with the computer while the careers teacher can interpret and evaluate the results of the dialogue.

As a practical experiment, ISVD only got as far as the laboratory stage before the grant ran out. ISVD is not yet ripe for a field test. Pending further grants, Tiedeman is allowing the project to lie dormant

Dr. William M. Shanner, American Institute for Research, Palo Alto

The PLAN project

PLAN is a CMI system for grades 1-12. Existing course material is used. The system is based on 14-day modules followed by tests.

The aims of PLAN are:

to improve the pupils' opportunities of devoting themselves to activating studies

to relieve the teacher of certain routine tasks.

The teacher in the classroom has many non-teaching activities to attend to. These activities, which are often extremely prodigal of time, can be taken over by the computer.

A recent report shows that at present the project includes:

16 000 pupils in grades 1-12, mainly in language arts, mathematics, natural sciences and social studies.

51 different schools (throughout the country) in 21 different geographical areas of the USA.

Approximately half the 16 000 pupils now taking part began this year.

A centrally situated computer in Iowa takes care of communications between the schools via optical readers and teletype terminals.

Last week 62 000 transactions(queries) were made by teachers and pupils while 12 000 tests (involving 16 000 pupils altogether) were administered.

PLAN is now a commercially operative system which the school districts or schools themselves have to pay for. The actual development work was concluded a year ago. Thus the product is commercially available to the school districts.

Follow-up of the project takes the form of a series of conferences with school administrators and others in need of information about PLAN.

Question: How can you produce a CMI system for so many schools with varying curricula and syllabi?

Shanner: We have developed about 3 000 course programmes, which means that pupils, teachers and schools have a host of alternative possibilities to choose from. We have developed a series of two-week modules and it is our belief that they can fit into different syllabi in any number of ways. At the same time, though, we take into account the minimum requirements laid down by the school district or the state, e.g. in US history, certain health courses and suchlike.

We also investigate the question schedules kept by the student and his parents and showing what the student wants to go in for. We also make allowances for what is shown by his test scores and test profile.

Question: What difference is there between IPI (another, similar CMI system) and PLAN?

1 IPI has what are termed natural learning units, while PLAN uses time as an organizational unit: fortnightly periods. In certain cases it is possible to complete a task in this time while in other cases it takes longer: three weeks. The time

varies far more in IPI than it does in PLAN. In the PLAN project you can decide on the basis of periods of 2-3 weeks what the pupil is to go on to.

2 The PLAN student uses the ordinary course material available on the market, while IPI presents the student with specially constructed material.

3 In PLAN one student may encounter a particular item in the form of printed material while another will be given it in audiovisual form (though they are both given the same tests). In IPI all the students encounter more or less the same material.

4 The PLAN material gives the student a base sequence and modifies it to suit him. IPI is more of the line-programming type. In other words, PLAN is more flexible and, consequently, has a bigger guidance component than IPI.

In many respects. however, IPI and PLAN resemble each other.

Question: Is there any different between the testing methods of the two systems?

Shanner: The students are not given any numerical scores in PLAN. All the test does is to show which objective a student has attained or failed to attain. For instance, he may pass three of five tests and then be taken back to material enabling him to pass the two he failed. The IPI student is tested on what he has studied. The object of the test in PLAN is to show what the student can do after he has studied a particular section.

Question: Is there a future for the CMI idea in schools?

Shanner: American schools have never taken efficiency seriously and have never desired to work for it. The percentage of time per day devoted by students to active learning is very low, perhaps as low as 10 per cent. Of course, we cannot expect students to be 100 per cent learning-efficient six hours a day, but CMI can probably raise their efficiency.

There are a host of problems in school that we have not solved. It is not necessarily aptitude but time and practice that correlate most with performance. The time and practice devoted to a subject seem to correlate with performance achievement as much as anything else.

The theory behind the PLAN project is that if learning tasks can be redistributed as regards both teacher and student in the course of a six-hour school day, we can expect the percentage of time in which each student is engaged in active learning to rise from 10 to 15 per cent without any changes being made to the ordinary teaching material. In this way one could achieve

better student performance all down the line. The novelty in PLAN is that we have introduced a kind of management instructional system. But we have not made any alterations to the normal presentation of the teaching material. Nor have we made any alterations to text or audiovisual elements.

The problem of course is to analyse the activities which go on in the classroom. This means that we have to find out what things are of an instructional nature and which are of a non-instructional nature. In an ordinary classroom situation, 90-95 per cent of the communication comes from the teacher. In a situation where individualizing material occurs, 70-80 per cent of the communication comes from the students. Two-thirds of the communication in a group is of a noninstructional character, for instance, "get out your pencils", "open your books" and so on. There is nothing intrinsically surprising about this. A lot of instructions are needed to get 30 students started on something. In the PLAN project the instructions are given to the student in writing and consequently do not take up anything like the amount of time they require in ordinary teaching(in PLAN two-thirds of the material is of instructional character and only one-third of non-instructional character). The strategy of conventional teaching seems to be for the reacher to let the subject matter pass through the student, while in individualized instruction of the PLAN type you try to do the opposite, i.e. take the student through the material.

Question: Are any new CMI projects going to be started in the USA?

Shanner: Certainly. Of course, PLAN does not solve all the problems in the CMI sector, rather it is to be seen as a prototype. One problem is that we have to develp learning situations which are less dependent on printed material.

The PLAN project includes obtaining details from the computer as to what the students can do and what the teacher should do. We can then read off exactly what students have done during a given time, what results they have achieved and so on. This means that the teacher need not go to the trouble of collecting that information. It is already available via the computer terminal. The teacher does not need to have a registration system of his own.

Another important experience we have gained is that the students learn a great deal from each other. Some students can even perform teaching tasks in the classroom. Students may perhaps be more efficient at reaching their classmates than the teacher is. A student who is having difficulty with a particular item, say item 4, can look at a list showing which students have done this item and he can then ask one of them. He should not contact the teacher unless the student in question is unable to help him.

Dr. Dexter Fletcher, Stanford University, Palo Alto

Dr. Fletcher is Research Associate at the University, which means that he has practically completed his doctoral thesis. He has mostly been occupied with the development of CAI material in language arts. He has been involved in the CAI project since 1965.

Fletcher:

Our CAI project can be said to comprise two phases. In phase 1 we had an IBM 1500, which was very expensive and cost 2 000 dollars per year and student, an amount which could be justified to a certain extent on the grounds that research was being conducted in connection with the experiment. It was not a suitable computer for computer-assisted instruction. This first phase comprised an initial reading course and mathematics courses from grade 1 to grade 6. The computer equipment also includes a CRT screen and a light pen and a slide projector (random access). Thus our data system was a very well-developed one and we believed in the idea that the better the equipment the better the instruction. In the experiment the computer took charge of most of the teacher's functions.

The experiment taught us an expensive lesson and we realized that we could not go on this way. In the next phase, therefore, we endeavoured to make the experiment as simple and inexpensive as possible. It was at this stage that we started using teletype only. We have also given up the idea of putting all or virtually all the subject matter into the computer. We have learned that only certain parts of the subject matter are suitable for computerization. It seems reasonable to programme the parts you know you can give a good presentation of. This means that you have to analyse the course and select the parts that are suitable for computerized learning.

The computer with CRT screen is superior to the teletype equipment. This is particularly true in the case of language teaching. A text can be presented more quickly with CRT and if you are going to learn a foreign language via computer, some form of sound equipment is needed. Access to a cheap CRT screen and sound equipment controlled via a computer would open the way to big developments in this sector.

But one can also conduct many interesting experiments with teletype equipment. After all, we know so little about teaching and learning. But there are a lot of questions concerning e.g. the problems of how long the "steps" should be, how much time the student should spend at the computer, problems surrounding question and answer techniques and many other things requiring a great deal of methodological development which is not intrinsically dependent on advanced equipment. We will have to

do more research into these matters. The really interesting thing is to establish a dialogue between student and computer or between student and programme, something which Suppes in particular is interested in developing. My attitude is that we still do not know enough about natural language to be able to create a truly meaningful dialogue system for CAI.

Question:

One item of criticism that has been voiced in many parts of the USA is that you hardly need such complicated apparatus as a computer to transmit the subject matter which is being transmitted by computer in present CAI programmes. A simpler teaching machine costing just a few hundred kronor is quite enough. How do you feel about this?

Fletcher:

One has to remember that we are only at the beginning of what will probably be a long process of development. People did not talk about cost/effectiveness when motor cars came in either, and it is a mistake to talk in terms of cost/effectiveness at the beginning of a long development process. The discussion which has occurred as to whether one should keep to "cognitive" subjects is a practically impossible one because nobody can describe what a cognitive subject is or what parts of a subject are cognitive.

Question:

Have you carried out any experiments in other subjects besides reading, mathematics and language arts?

Fletcher:

Yes, we have penetrated a wide range of subjects, but perhaps the most important thing is that we have built up a techniques for CAI which can be applied to any subject.

Question:

The CAI programme is frequently criticised on the grounds that it is not properly integrated with teaching generally, that is with the teacher's actions and with other aids.

Fletcher:

Yes, there is certainly something in that. But we are trying to computer-base those parts of the subject which fit in with the teaching process.

Dr Bruce Harlow, Director, Stanford School of Education for Research and Development in Teaching, Palo Alto

Mr Harlow began by going over an organizational chart of the institution and gave an account of three separate "programmes" or problem sectors at the centre of its research and development work:

1 Heuristic teaching
2 Environment for teaching
3 Teaching students from low-income areas.

The object of the first of these programmes is to create a model programme designed to create teaching which will make the pupils interested in arriving at their own answers to certain questions (the word heuristic comes from the Great "Eureka" - I have found it). An investigation is also being made of what things can be done by the human teacher which the computer either cannot do at all or cannot do as well. Programme 1 has also included the collection of data on teacher behaviour and measures taken by the teacher in the teaching context. Work has been in progress for many years on the compilation of a comprehensive data bank for the project.

The second programme is concerned with the surroundings in which teaching can be conducted. Micro-teaching is being considered, as are the different personnel categories assisting the teacher. The third programme is devoted to research into the teaching of students from low-income areas. In this sector Dr R D Hess has written a thesis on the computer as a socializing agent.

Hess' survey covered children of Hispano-Mexican origin at Junior High School. The computer-based courses are in mathematics. Attitudes to the computer as a source of information are compared with attitudes to the human teacher. Generally speaking these children showed a more positive attitude to the computer as a source of information than to their teacher.

Dr. Francis Sobol, Florida International University, has constructed a classification system for what can be required of a teacher. He has endeavoured to computer-base this taxonomy. A technical report will be available in a few months.

Dr. David Aaronson, Systems Development Corporation (SDC), Santa Monica

Dr. Aaronson works at the Corporations's CAI centre and is responsible for the PLANIT project, i.e. the development of a programming language for interactive instruction specially designed for CAI.

The programme language is designed in such a way that it can be transmitted to different kinds of computers. The purpose of PLANIT is to evolve a programming language which will be suitable for computer-assisted instruction regardless of language, level and computer. The language is constructed to resemble natural language and it can also be translated e.g. into foreign languages without any difficulty. The idea of PLANIT is for the teacher wishing to make a CAI programme to be able to use the language after only one day's training. A teacher wishing to use the computer for CAI should not have to penetrate two different subjects, i.e. learn to arrange a CAI programme and also learn a programming language. Efforts are being made to build on natural language to the greatest possible extent. To obtain a

lesson via the computer one writes "get", to execute one writes "ex", to save a lesson or part of a lesson one writes "save" and to insert something in the computer one simply writes "i".

Dr. S. Coulson, Systems Development Corp, (SDC), Santa Monica

Coulson feels that CMI (Computer Managed Instruction) ought really to be termed CAIM (Computer Assisted Instruction Management). The Term "computer-managed instruction" gives one the impression that the computer makes all the decisions about what is to be taught. As Coulson sees it, decisions still remain the teacher's responsibility. The main difference between ordinary teaching and CAIM is that the teacher receives feedback and prescriptive information about what should be done in order for the student to attain different learning goals.

Thus the purpose of CAIM is:

to give the teacher an opportunity of adjusting his teaching to the student's rate of progress,

to indicate sub-skills in which the student needs auxiliary instruction,

to indicate what prescriptive instruction or auxiliary instruction the student is in need of.

SDC developed a CMI system called "Instructional Managenent Systems" (IMS) in reading and mathematics, grade 1, for Southwest Regional Labs(SWRL). The system was run for 2½ years in a number of schools in Los Angeles (solely for a preliminary trial). SWRL then took over. The students are given AA equipment (earphones/ microphone and group tape recorder) and pre-recorded tapes telling them how to work through the material. Stimulus material is provided in the form of printed sheets. The students have to match picture and words and supply an answer. Their answers are corrected by an optical reader. The system incorporates group tests, group reports and reports on each student. The computer is used batch-mode, which saves time and money. CAIM is far cheaper than CAI, probably costing no more than 1/5 as much. CAIM gives the teacher rapid test results together with other feedback from the students' activities. By contrast, most CAI systems are unable to provide good diagnostic summaries of the students' performance throughout the course.

Question: Some critics have said that the individual data, i.e. the data concerning the student's background, environment and achievements included in the majority of CMI systems are too limited for CMI to be a feasible proposition. How do you feel about this?

Coulson: Yes, of course we need more information. But at the same time one can ask: Do we know so much about learning that we can make use of the individual data available? Personally I do not think we do.

Question: What kind of individual data do you think are of value in making a CMI system work in the teaching context?

Coulson: The data we have in our IMS system are enough. We do not know what further decisions we require the help of the computer with. Certain systems have been made to include different kinds of personal data: interests, attitudes and so on. But I have not seen any system that has been able to utilize this information in a meaningful way.

Question: Can CMI be used for all subjects or is it best suited to certain subjects, base subjects, perhaps?

Coulson: No, I think CMI can be used in all sucjects. Like CAI and programmed instruction, CMI presupposes that one can obtain concrete behavioural objectives. For instance, CMI can hardly mean anything in literature and music appreciation, where it is difficult to measure the progress made by the student. CMI, then, is dependent on our ability to measure objectively the students's progress, and this requires clear, concrete learning objectives.

Question: How have you solved the problem of updating?

Coulson: That is our heaviest item of expenditure, a heavier item than the cost of using the computer. But methodologically speaking it is not a very difficult problem.

Question: What is happening in the CMI sector: Are many new CMI projects being started?

Coulson: No. Here as with CAI, there is a shortage of research funds. But a new CMI project in reading involving about 15 000 children was started in Los Angeles. In purely commercial terms CMI has not been a very great success, and the same applies to PLAN. But I believe that CMI will break through one day.

Question: What do the teachers think of CMI?

Coulson: A survey we carried out indicated that the general attitude was positive. But a great deal depends on practical things. The work input on the teacher's part is very important. Our project meant less work for the teacher in connection with cataloguing, auxiliary material and so on, and this was appreciated. On the other hand they showed a negative reaction to a couple of extra forms which they had to complete every week.

Question: What do you consider to be the difference between your system (IMS) and Robert Glaser's IPI?

Coulson: IPI was developed on the basis of a set of teaching material which then became a managed instructional system aimed at following the progress made by the students with the material constructed. But IPI is still a kind of semi-manual system compared to our IMS. IPI is dependent on a host of teacher aids which have to do a great deal of the work. Like PLAN, IMS was constructed to be used with any kind of teaching material.

Question: Then what is the difference between IMS and PLAN?

Coulson: PLAN uses much larger modules: 2-3 weeks, while our module only covers one day. PLAN is also concerned with guidance, while we are only concerned with the student's achievement while he is learning. PLAN is based on teacher-generated instruction while IMS is based on more specific instruction (which could be generated by the teacher). PLAN is also designed to give advice and instructions as well as providing a diagnosis of the student on the bases of a battery of tests. PLAN costs 100 dollars per student p.a. whereas IMS costs 1 dollar per student p.a. PLAN is tailored to a particular data system while IMS can be used in various data configurations.

Question: Do you believe in the computer as a test instrument, i.e. can computers be made to perform more advanced tasks than correcting multiple choice tests and working out tests scores?

Coulson: Allen Page has done a study in which he has tried to show different development possibilities. He contends that we do not need to use such sophisticated tests as we imagine. Often teachers do not use a particularly advanced system for marking précis-writing or essays. Allen Page programmed a computer for marking essays. He went by the number of words, syllables and unusual words used on average. By using 5-6 simple criteria of this kind he attained a high correlation, about 80 per cent, with manual marking. But it would require an enormous data capacity to take into account all the syntactical problems involved by language.

Dr. Richard Schutz, Southwest Regional Laboratory for Educational Research and Development (SWRL), Santa Monica

SWRL have developed a CMI project which is mainly concerned with reading. This system, known as IMS (Instructional Management System), can however be adapted to any subject. It is a type of planning model for a subject. The model has been made to include a preliminary test and a host of diagnostic tests.

A meticulous goal description has been compiled for IMS. A distinction is made between general and specific learning objectives. As a rule, general objectives consist of a group of specific objectives covering a prolonged period (several months or a whole term). Matching figures which are identical as regards size, shape or content is a typical specific learning objective which is included in the general objective "visual matching".

Tests administered once or twice every week enable the teacher to follow the student's work in detail. The tests are marked via computer. The teacher obtains the test results immediately. These results also include the average score of the group on each general objective. The computer supplies the teacher with information on the students' performance in each test (both general and specific). He also obtains each student's test profile together with information of the student's performance in previous tests. Study recommendations are also given via the computer for each student. It is then up to the teacher to decide whether to follow these recommendations or modify them. More detailed instructions regarding auxiliary tasks for the student are not computer-based, however. A code-number via the computer gives the teacher the orientation he needs.

According to Schutz, IMS is an inexpensive CMI system. The cost per student p.a. is 1 dollar as against 100 dollars in the case of the PLAN project.

In order to keep track of the student's achievement in a CMI system it is an advantage to have access to microfilm, microfiche and some form of hard copy.

Mr. T.S. Hancock and Mr. D. Dooley, Education Service Center, Houston, Texas

Houston is the largest of 20 regional data centres in Texas. These centres were started in 1967, when a plan was drawn up for data services to schools in the state. The Houston centre serves about 600 schools numbering over 500 000 students.

The data centre has three main functions:

1 to supply computers for the teaching process in classrooms (e.g. for problem solution, drill and practice)

2 to provide data support above all for vocational data processing classes

3 to perform data services of various kinds (e.g. salary computations, timetable construction, diagnosis).

The school districts enjoy a great deal of independence within this computer system thanks to the so-called RJE terminals (see B in the enclosed figure illustrating the hardware in the system). The districts are connected to the two large computers but can nonetheless act independently, among other things, in

a) using the terminals as satellite computers quite independently of the central computers for running their own programmes

b) using the large computers at the centre to process their own data

c) using their own programmes for processing in a large computer

d) using the satellite terminals locally for teaching purposes.

On the other hand there are no standardized and common data for all the school districts in the system. There are a number of standardized national tests, but the school districts are at perfect liberty to use whichever tests they like, so that the test results are not included as a common component in the data base. Grades are not uniform either: certain parts of the state use a combination of letters of the alphabet while others make use of a combination of figures and others again use a combination of both letters and figures.

Computer-based teaching material registration exists, among other things in the form of a register of teaching materials for remedial instruction among handicapped children. Thus lists of teaching materials can be printed as required, but ordering routines have not been automated, although good progress has been made in this direction.

The centre is also building up a "Job-occupation" data bank, the aim being to create a register which can be used via the remote terminals. In this way students and vocational counsellors will be able to ask for facts from the register which will then be forwarded to those asking for them.

The table below reflects the scale of the data services offered by the centre.

REGION IV COMPUTER SERVICES PARTICIPATION 1970-71

	Student Master file	Student Class Scheduling	Grade Reporting	Attendance Accounting	Test Scoring	Instructional Time Sharing (CAI)	Vocational Remote Job Entry	Payroll
Districts	29	26	20	23	33	22	10	24
Campuses	232	77	115	182	464	86	10	
Students Served	184,506	89,810	105,062	147,658	323,477 (Tests Scored)	37,500	700	25,000 (Checks Printed Per Mo)

The local school districts are calling for increased computer automation for planning and administration purposes and also to give them access to sophisticated aids in the teaching process.

A management information system is needed for long-term planning. By the end of this year experimental activities will have started using an integrated file handling system in which the school districts will have access to the registers kept on a decentralized basis at certain terminals. CRT and other forms of visual reproduction will be used. It is realized that a great deal of training will be needed to get the system implemented in the school districts. There are no finished programmes, instead all the different pieces in the system have to be tailored to their purpose.

Dr. Paul Merril, Florida State University, Tallahassee

In Dr. Merril's opinion the following areas of application can be distinguished for the computer in the education sector:

1 Data analysis
2 The computer in school administration
3 Resource scheduling
4 CAI
5 CMI
6 Simulation
7 Problem solving, i.e. the computer as a calculator
8 Information and documentation

Resource scheduling implies the use of the computer in distributing and keeping track of the teaching materials, equipment and premises used within a school system and often pooled.

Automated testing can be regarded as a sub-sector of CMI.

Automated testing implies that the computer presents the student with current items, computes his score and "diagnoses" his knowledge on the strength of his answers.

Merril:

We have also tried to automate the so-called SLAS test, which is a one-to-one type of test used by a psychologist together with a student. Usually this is a very expensive testing procedure.

The test requires fairly sophisticated natural language processing and is therefore quite difficult to construct. The questions are open-ended and the student answers in natural laguage. This means that the computer must be able to interpret his knowledge. But these test problems are not unduly complicated by comparison with the problems normally arising in connection with natural languages, because the questions can be kept within a particular answering sector. We have been quite successful on this point and have achieved a high correlation between open-ended question tests via the computer and normal testing procedures (using a one-to-one type of test with a psychologist only). A high correlation has also been achieved with other tests.

Question: How do you solve the input problem in this context?

Meril: Via a computer terminal with a CRT screen. The students write in the information via teletype. The computer is programmed for certain keywords. If the computer does not "understand" it asks for additional information.

Question: What types of student answers can the computer process?

Merril: The computer can easily handle multiple choice questions and answers. It is also easy to programme very short answers (e.g. in mathematics).

As soon as you come on to open-ended tests in which the student has to make a verbal statement comprising 2-3 sentences, things become more difficult. The same thing can be expressed in many different ways and it is hard for the computer to process many different answers and synonyms. If the pupil is to give a

definition of a word, the programme must contain a sufficiently large number of synonyms to cover the definition. One method is to programme in a given number of answers and let the student write a limited number of key words. There may be a certain connection between these key words which the computer is able to sense. If the student uses incorrect key words or gives an incorrect statement of the relations between key words, the computer can supply the appropriate feedback.

Another things we are working on is known as sequence testing. Sequence testing means that the student is given a number of questions focussing on his knowledge within a particular test sector. If the test is concerned with mathematical models, the computer programme will take into account not only the student's previous answers and test score but also the certainty and knowledge he displays. The computer also registers the time it has taken the student to answer. On the basis of preceding answers, test score and the quality of the answer the computer then indicates the test item to be presented to the student in the next step.

The main idea of sequence testing is to offer the student a whole series of test items based on an algorithm and so make it possible to offer the student the minimum number of test items necessary to guarantee a good test result. In the first instance these experiments are aimed at reducing testing times and test work. Quite a lot of this test methodology is now being applied within our CMI projects. Automated testing and sequence testing are extremely costly but at the same time they are to be regarded as rational because they reduce the time which has to be devoted to the actual test. Conventional tests carried out by psychologists cost a great deal. Computer testing should lead to reduced costs per student test.

We have also used the computer in medicine and in certain information-sensitive sectors, e.g. programmes on sexual matters and drugs. Especially on these subjects, many students find it easier to "converse" with a computer than with a human being. For many students the computer seems to provide neutral and objective information. It also seems to be less pregnant of emotion than is often the case with human contacts.
Our experience indicates that students would rather consult a computer than their teacher on matters concerning sex and drugs. In a medical examination, to take another example, one could therefore imagine a computer asking the standard questions normally put by a doctor in a particular situation, processing the answers and presenting the results to the doctor when he attends to the patient. But we have only limited experience of this computer sector.

The use of the computer in a sector where the student feels that he can ask delicate questions and obtain more "neutral" treatment than in the normal way is a new and promising field within the CAI sector.

We have also tried using the computer as a research instrument. The computer gives us greater control over the variables included in an experiment. Thus with a computer one can achieve exact control of the material which a student has to learn. The computer can also regulate the speed at which the subject matter is to be presented. One can also check that the student does not go back to consult earlier material (if by any chance one should have occasion to check such things). One can also use the computer to handle experiments including many different kinds of data from treatment and actions. Thus the computer can be used to register data and students' answering times.

Dr Philip Duchatell, Florida State University, Tallahassee

Dr. Duchatell works at the Computer Assisted Instruction Center (CAI-Center), which is a special unit ancillary to the university data centre and exclusively concerned with computerized instruction.

CMI projects

An interesting experiment is in progress in the field of what is termed programmed instruction. The student is given ordinary teaching material (text books, work books etc) which he reads (off-line). At regular intervals he visits this CAI centre, registers and is given a series of questions via the computer, which also supplies answers, thus providing a type of feedback. In this way he can see approximately where he stands and how much he knows. If he makes a mistake he is given either a correction or a comment. The CMI course sometimes covers an entire term. The course is divided into 20 modules. A number of objectives to be attained by the student have been drawn up for each module. In one and the same module the student is confronted with 20 questions. The student can ascertain for himself whether he has attained the predetermined goals. Thus a great deal of the responsibility for learning is entrusted to the student himself. The students do not use open-ended answers, only multiple choice ones. Research is being done into the use of multiple-choice answers, but this is a difficult problem because it is hard to give reasonable clear and unambiguous answers of this kind. The root problem, of course, is that the student understands the computer better than the computer understands the student.

The course has been used for two years. It also includes teaching the student to write a short programme, though this programme is not written for a computer. The data received through the stundent's answers in the CMI programme are collected so that they can be analysed to see how well the student has coped with the items.

The equipment used comprises a PDP-8 acting as a module changeover for a larger computer, an IBM 180C. The mini-computer operates the 8 teletype terminals used by the students for the

CMI programmes. CRT screens operating together with the IBM 1800 are also included. There is also a teleprinter, a card punch and a punch card reader. Finally there is a PDP-9 which acts as a module change-over between the IBM 1800 and the teletype terminals, which can be 240 miles away. The latter equipment is used by students at junior level, where a certain amount of research is in progress. Altogether there are 16 CRT terminals and 15 teletype terminals within this centre. The installation has been in use since about 1965.

Mr. Floyd Howe, Director of Computing Services, Miami Dade Junior College, Miami

Joseph Duerstock, Associate Director of Computing Services, Miami Dade Junior College, Miami

Question: Has the computer been used as a calculator at the University?

Duerstock: For over a year now the institutions of physics and mathematics have been using the computer for this purpose. They have reported highly positive experiences. Both teachers and students work with the computer equipment (IBM 360 and IBM system 3). Sometimes batch processing is practised. One experience that has been reported is that drop-out among the students declines when the computer is introduced into teaching. In one course (accounting) the drop-out rate was about 50 per cent. Since computer-based courses were introduced it has fallen to zero.

Question: What experience do you have of the computer as an aid to school administration?

Duerstock: Broadly speaking the introduction of the computer into school administration is a question of sound planning. A positive attitude to the change-over to a computer-based system is important, i.e. administrators, teacher and others concerned must feel and experience that what they get out of the computer is valuable and important in their work. But they have to experience this if the new system is to be accepted.

From the administrative point of view we are in favour of a student registration system constituting the entire gambit for the introduction of a computer-based information system. Our data system includes the admission of applicants, grade reporting, salary routines, stored inventory, registration of students' test scores and so on.

Question: Have you tried computer-based timetable construction?

Duerstock: We did try it recently, but that was only two months ago. We have carried out two experiments. The first one was only 80 per cent successful while the second, which was very simple, was 99 per cent successful. But we are still uncertain as to whether it can be done.

At one school we have full periods and that of course is easy to plan a timetable for. But difficulties still arise, due partly to the teachers working in teams and partly again to subjects being scheduled in blocks. Difficulties also crop up as a result of students changing their minds at the last minute.

We assumed that we would have to programme a manual timetable and so far we have based everything on logarithms. Computerized timetable construction generally is something of a trial and error business. There is no direct mathematical solution to the problem.

But we are working on the matter and we are very interested.

Question: What is your view of the idea of a total information system?

Duerstock: In practice there is hardly any total information system in existence. A total information system would mean a system in which there are links between different registers and in which a student can be retained in one register even if he is not eligible for others. A total information system is extremely hard to construct because you do not know what relations apply between different registers and different departments. The fees which have to be paid by the student may come under the finance section but at the same time they are part of the business of registration. The same particulars have to be made available in several different places, which makes things extraordinarily complicated. This means that you have to define all relations between the different tasks and registers before you can even think about doing anything else.

Purely theoretically speaking, you can construct a system of this kind, but when you then try to put it into operation circumstances have changed so that everything has to be done differently. This way you simply end up chasing your tail. There are no general solutions for a total information system. Everything must depend on the particular school system. For instance, the University of Michigan has to construct a completely different total information system from, say, Miami Dade Junior College - an open community college - among other things because the University of Michigan also has to include data on student accommodation.

Question: Have you tried to construct any kind of information system at this University?

Howe: Yes, we have made various attempts but we have run into so many problems that we have for the time being abandoned the idea of creating a large information system.

Instead we have begun to discuss the possibility of storing information in another way than by computer. In some cases information may have to be stored on microfilm or microfiche.

The greatest difficulty lies in developing a system which will rapidly supply us with the information available. One system which is thought to be quite cheap is Memorex microfilm. We are planning to transfer a great deal of information to microfilm. Something must be done to prevent our libraries bursting at the seams with reports and documents.

Dr. J. Tresher, U.S. Office of Education, Washington

ERIC (Educational Resources Information Center).

Tresher: Something which people tend to forget about ERIC is that, while it began as a pure information system, since 1967 it has constituted an information analysis system, i.e. researchers at our clearing houses read journals, books and so on within a particular sector, synthesize the information, assess it in the light of their experience of the sector and analyse it. A large proportion of the publications issued by ERIC are primarily analytical.

One of our problems, however, lies in obtaining the financial resources for publishing our work. Another is to find the time and money to answer all the inquiries that come in. Last year we nonetheless replied to 60 000 - 70 000 inquiries, but this was still not enough. A third problem: we are constantly meeting people who say that they have never heard of ERIC and that they could have used our services if only they had known of our existence.

Question: Have any updating problems cropped up yet?

Tresher: Yes, we have noticed them. But ERIC is so new that we have not yet had to discard any material. But sooner or later the problem will arise.

Question: How much does ERIC cost altogether?

Tresher: The budget for the entire system is in the region of 4 million dollars annually. Each clearing house (there are 19 at present) costs about 180 000 dollars a year. This does not include certain donations.

Question: What are your plans for the future?

Tresher: We have certain plans (not too articulate as yet) for the establishment of Educational Agents, that is educational experts following the example of the agricultural sector by travelling round to the schools and giving good advice about how to solve certain problems concerning organization, methodology or teaching materials. We are conducting certain experiments at present but we do not know how far we can go. Another problem is that our existing 19 clearing houses are not equal to the task of serving as information centres. Centres of this kind could be established within a school district or a state. They could use the same data base of information as ERIC. At the moment we are studying whether these information centres are to function on a local or regional basis.

We also want to advance further as regards the analysis of information and the evolution of better products. We have realized that we cannot concern ourselves solely with products dealing with research. We also want to reach the practitioner outside, the teacher and the school administrator. Significantly enough, we altered the original name the Educational Research Information Center to the Educational Resources Information Center, a change which reflects the change in our objectives.

Dr. Roger Levian, Rand Corporation, Washington

Dr. Levian has led a project financed by the Carnegie Commission and aimed at investigating the possibility of using computers in higher education. One of the tasks of the project was to structure the sector "the computer in teaching". It was found that a distinction should be made between:

1. the computer as used in administration and documentation
2. the computer as used in teaching
2.1 computer education and the teaching of data techniques
2.2 teaching with the aid of the computer, i.e. the computer as an implement in the teaching process and as a substitute for some other implement, e.g. TV, calculator, book or even teacher.

Levian: The greatest problem in using the computer as an aid to teaching lies in the difficulty of establishing an organization guaranteeing the production of good and adequate teaching programmes for the computer. There is an organization of this kind for printed teaching materials. Where educational software for computers is concerned, there is a complete lack of all the forms of encouragement (royalties, copyright, prizes of different kinds) existing in the field of printed materials. The absence of a sales organization also entails several disadvantages. At present there are many teachers in different parts of the country busy designing data programmes for practically the same sector or item.

Question: How can one get out of an impasse of this kind?

Levian: One way is to go in for a large central computer with time sharing which serves not just one school sector but many, it can perhaps be specialized either regionally or by subjects. A number of different data programmes can be located in this data system. In this way many people can (via terminals) have access to the same material. The development of so-called multiplex techniques will make it possible to establish contacts with other large central computers in various parts of the country. What we need, though, is a publishing house type organization to develop and produce the software, improve and supplement the material and produce supplementary material (material used side by side with computer activities). Every time a student then uses a programme he can be charged a given fee which can also include royalties for the author and remuneration for the publishers.

Question: Does not a system with a large central computer and many terminals mean formidable telecommunications costs?

Levian: If you use multiplex techniques and let 20 teletypes use a voice grade line, the cost is only 1/20 of that involved by one time. There are also other ways of reducing telecommunications costs, e.g. by means of microwave techniques.

Question: CAI has been severely criticized in many quarters in the USA. How do you view the possibilities of developing of the computer?

Levian: I never use the term CAI, for many educationalists it is like a red rag to a bull. Many people see CAI as a way of presenting simple courses with a stereotyped programmed teaching material which only caters for mechanical learning. Do not let us speak about CAI, let us speak instead about different ways of using the computer for teaching purposes. One way is drill and practice, another is tutorial mode. At Potsdam, a state university in New York, the computer has been used to teach students the theory of music. A computer-based course has been constructed which is a mixture of drill and practice and tutorial mode and it works perfectly. Every year 500 students complete the course with great success. It helps the teachers with the difficult problems of individualization. Another example is the Russian course at Stanford, where drill and practice has been combined with a learning studio and text books. Although the computer here is used for fairly simple drill exercises, the course has been shown to produce better results than the parallel course, which uses the same material but does not include computer instruction.

Thus there are a host of sectors of application for the computer in education and these must be analysed to find out where the computer has an important part to play. Probably we overrate man as a lecturer, instructor and teacher. The computer is probably capable of taking over certain tasks and doing them as well as or better than the human teacher.

Question: During our travels in the USA we have encountered many different opinions of CMI. Some educationalists regard CMI as the most promising sector for the computer. How do you feel about CMI and its possibilities?

Levian: As far as higher education is concerned there is every reason to believe in CMI as an important sector of use. It is probably in higher education that efforts should now be made to use the computer. Compared with basic education the costs (per student) are far higher, which makes it easier to argue in favour of teaching with the aid of computers. Another thing is that students at higher levels are better able to utilize the interaction which the computer affords.

Mr. Thomas Byrne, Kiewit Computation Center, Dartmouth College, Hanover

Byrne

In 1964, when we began to make use of the computer, we were convinced that it was important for all students - and not just students of the natural sciences and technology - to be able to control and programme the data power. This philosophy posed two problems: how were we to introduce the computer for 3 500 students and how were we to create the financial resources needed to do so?

We soon realized that batch processing could not be used because this would mean 3 500 students queuing up in front of the computer with all the small jobs one could expect them to come along with. A better way of tackling the problem was to use a so-called time sharing system. The first time sharing system in the whole of the USA was created here in 1964. The development of good software was just as important as obtaining good hardware. This was done by creating a programming language, a simple language called BASIC which is now used everywhere in the USA and in other parts of the world.

To induce the students to use the computer we made problem solving obligatory for all newly enrolled students. Within four years 80 per cent of the students were using the computer in various connections. But one also has to convince the members of the faculty. Indirectly they became interested when they saw their students solving more problems in a better way and in a shorter space of time than usual. The teachers themselves began using the computer in their teaching, among other things for CAI-oriented tasks. For instance, geography students were made to learn cartographical symbols with the aid of the computer which left the teacher more time for more important tasks. All the teacher had to do was to say: read chapter so and so in the book and run programmes 1-5. Then he could go on to present more important subject matter. In other words, the computer gave him more time for the introduction of new areas.

In Dartmouth there are 150 terminals distributed between 25 buildings on the campus. During a typical day about 2 000 users can check in on the system. Thanks to the large number of terminals we acquired a surplus capacity. To prevent the data power lying idle we applied for and obtained a grant from the National Science Foundation to spread the system in New England to the lower school levels (including secondary schools). There are now five regional sub-branches which also cross the boundaries into other states . The system is used by about 10 000 students.

Our point of departure for using the computer in teaching was that the computer-aided activity should form a natural part of the teaching process, as natural a part as, say a library. In the case of the faculty members the availability of data power can give rise to a so-called spin-off effect in the form of increased research because they do not have to apply for special funds to be able to do research with the aid of the computer.

This research can then have results which gain the University grants e.g. from federal funds.

This generosity on the part of the University regarding the use of computer facilities is connected with the fact that Dartmouth received the computer free of charge from General Electric as a kind of gesture of gratitude for our evolution of a workable time sharing system. If the University had had to buy the computer the costs would by now amount to some 1 3/4 million dollars. As it is, computer costs now stand at no more than about 500 000 dollars.

We regard it as a factor of strength that the Dartmouth system is tailor-made for primary use within education. Another advantage of the system is that it is subject to constant revision because students and teachers from all faculties are continually using the programmes. In this way errors and inadvertencies in the programmes are more easily spotted and rectified.

Off-the-peg CAI programmes involve certain problems. It is difficult to make them so general that they do not need to be adapted for use within particular sectors. We fiil that we are solving this problem by letting everybody who uses the computer tailor his own CAI material. Partly for this reason we are running a special project, COMPUTE, in which the teachers produce material for their courses with the aid of the computer.

As I have already indicated, certain lower school levels are also included in the system. We are now going to test certain parts of Pat Suppes' material and adjust it to the time sharing system.

Question: Do you have a management information system at the Universtity?

Byrne: The President of the University, Dr. Kemeny, who is one of the foremost experts in the data sector, is at present assembling a working party to try and evolve a management information system. Kemeny hopes to be able with the aid of a mini-computer for administrative routines and the University's large computer (time sharing) to create a model of the University's planning and administration with all the variables needed to forecast e.g. the development of pupil numbers and so on. In this way he hopes to find the answers to many what-will-happen-if questions. Even now the computer is being used to forecast how many of those enrolling in different courses will complete them. For instance, the computer is being used in the physical education sector to analyse the possibility of winning against other football teams (believe it or not).

We are also contemplating the idea of using the computer to envolve a selection system for applicants to Dartmouth, Yale and a number of other universities sharing the same catchment area. The main component of the system would entail evaluating the applicant's preferences and informing him of his prospects of being admitted to the universities included in his list. This could be termed a form of study and a vocational guidance.

"COMPUTERS IN SCHOOLS" (DIS) - Pilot Study 2

Background

It would be difficult to overstate the importance of computer techniques in commerce and industry and in public administration. Although it was not until the 1950s that computers began to be used seriously, computer techniques have already come to dominate developments in a wide variety of social sectors. No single aid or invention has ever made such a swift impact or led to such far-reaching transformations.

One large and important field of society has been relatively unaffected by computer techniques: schools and the educational sector. Our national school system comprises 1.3 million pupils, 100 000 teachers and 5 000 schools and has a total budget of about Skr 9 billion. Accordingly it is somewhat surprising that greater use has not been made of computer techniques in this sector, for the rationalization requirements which have been the decisive factor in the introduction and diffusion of computer techniques in other sectors are also evident in the field of education. However, there is a great deal to suggest that computer techniques will also be utilized in the educational sector within the near future.

Since the end of the 1950s, experiments and research have been in progress within the sector which for the sake of simplicity can be termed "computers in schools", in Swedish "Datorn i skolan (DIS). The computer activities concerned are many and varied and affect a wide variety of sectors in the educational system. Computers have been used in schools in England, Germany, Japan and Sweden too. A preliminary account of the uses to which computers have so far been put has been given in Pilot Study no. 1 (9.12.70) and in a report on a study visit to the U.S.A. (15.12.71).

Aim

The purpose of Pilot Study 2 is as follows:

1 to provide a survey of the use now being made of computers in schools and education

2 to evaluate the experience gained

3 to suggest action to be taken

Applications of the computer in schools/the educational sector

Many attempts have been made in the U.S.A. to classify the sectors of application of the computer. No commonly accepted classification exists at present. The following division is based above all on the tasks occurring within the educational sector.

1. The computer in administration and information

1.1 school administration:

salary routines, pupil and teacher registration, merit and absence registration, timetable construction etc.

1.2 information and documentation systems

2. The computer in teaching

2.1 computer-supported instruction

2.1.1 the computer as a calculator - computer-aided simulation

2.1.2 as an educational aid and control member (CMI, tests, syllabus instructions, study and vocational guidance information).

The computer is used to provide teachers and pupils with instant information (feedback) concerning the pupil's achievement in a particular test or the way in which the pupil has completed previous tests. The computer registers data concerning the pupil and his achievement as well as suggesting syllabus instructions, e.g. references to pages or sections in a textbook, to suitable exercises, to self-instructive material, to a tape. As a rule the teaching material is of a conventional variety and not computerized. A common American term is Computer Managed Instruction (CMI).

2.2 computer-assisted instruction (CAI)

Also of interest in this connection (among other things with regard to the possible combined use of hardware, systems ware and software) are:

3. computer education

3.1 computer training (for prospective programmers and systems men)

3.2 computer orientation (in comprehensive school and upper secondary school)

The above division is only tentative. No hard and fast lines can be drawn between the different areas of application. In certain American CMI projects, for instance, the computer is used both as an educational aid and control member (for marking, registrering tests etc.) and as a teaching aid (computer-assisted instruction). If the computer is used for simulation support this may concern sector 2.1.1, but simulation also occurs in CAI (sector 2.2). Ultimately it is to be expected that the same computer (mini-computer/terminal) will be used for many different purposes in schools. At present, however, some form of division remains a practical advantage, among other things for the sake of simplicity and convenience of arrangement.

Summary[1] concerning the use of the computer for purposes of school administration

Within the DIS sector it is above all the instructional use of the computer that attracts attention and large research grants. Yet in fact the computer is mainly used for administrative purposes. For some time now extensive work has been in progress in the U.S.A. on the use of the computer in school administration. Both universities and ordinary schools are trying to employ the computer as an aid. The work which is being done entails the construction of local computer systems as well as computer networks. The bulk of co-operation in the latter respects centres on the hardware, but in many quarters there are also plans for co-operation regarding software and systems.

Both in Chicago and elsewhere in the U.S.A. where the computer has been tested as an administrative aid in schools, an optimistic view is taken of the possibility of harnessing computer techniques in this context even though it is as yet hard to establish any financial savings resulting from the change-over to computers.

So far relatively little experience has been gained in Sweden within this sector. Such experience as has been acquired to date, e.g. in municipal schools for adults, where pupil, teacher and student grant registration together with various other routines have been computerized, has been favourable.

One prime condition for the utilization of computers in school administration is that highly comprehensive planning and rationalization work must be feasible at low cost. We know from industry and commerce that the introduction of computers in a firm has not invariably resulted in greater efficiency and lower administrative costs. One survey shows that only in about 40 per cent of cases can firms establish direct rationalization savings resulting from the adoption of computerized administration.

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1) The Swedish report gives sector-by-sector summaries of the utilization of computers and the experience gained thereby in the USA, Sweden and some other countries. Space will only permit the inclusion of the summaries in the English edition.

Summary: the computer used in information and documentation systems

Computerized information and documentation systems have existed for some years e.g. in technology, medicine and communications. In the educational sector too, a large system, the American ERIC, of international importance has been built up. The services of this system are utilized in Sweden, among other countries.

The LIBRIS system contains the embryo of a common computerized information system for Swedish research libraries. The possibilities of international co-ordination and co-operation will be kept under observation.

There are plans at international level for the development of two wide-ranging IoD systems - UNISIST and EUDISED. The first of these is primarily intended to cover the natural sciences and technology, while EUDISED is planned mainly to focus on pedagogics.

The IoD systems, which to begin with were exclusively retrieval-oriented (comprising indexing and "abstracting"), have now been developed with a view to analytical processes (the dissemination and utilization of knowledge).

This sector has great development possibilities. There is every reason for closely following up and in every possible way supporting the initiatives taken within it.

Summary: the computer as a calculator

In most parts of the world where the computer has begun to be used purely as a calculator, pupils have been given an introduction to computer techniques and in some cases computer training as well. In many cases this instruction has also included training both teachers and pupils in the rudiments of compiling a computer programme which can then be used for calculation purposes. In some cases this instruction has been taken one stage further to include certain elements of drill and practice exercises.

Pupils who begin by using the computer for calculation purposes accumulate a knowledge of computer techniques which can later be used in various ways, be it in calculation tasks, simulation support or computer-supported teaching programmes.

We therefore have very good grounds for supposing that the computer will come to play an important part as an aid to calculation in teaching, especially in technical subjects, mathematics and other subjects requiring a great deal of calculation. The main need is not only to develop programmes suitable for use in schools but also to integrate these programmes with teaching generally. Teacher training is another task to which a great deal of time and attention will have to be devoted.

Conclusion

The National Board of Education should initiate experiments to test the potentialities of the computer in pre-eminently technical subjects, mathematics and physics. Experiments at grassroots level should be aimed at eliciting answers to the following questions:

a) Which subject sectors, subjects and subject items are of such a kind as to make computer equipment of the utmost value to pupil and teacher?

b) What kind of software is to be used (ready-made programmes, programmes provisionally compiled by the teacher, simple practice programmes produced by the pupil)?

c) How is the computer to be integrated with the subject (a practical and pedagogical problem)?

d) How are teachers to be given further training and how are pupils to be informed?

Summary: computer-supported simulation

The use of the computer as a support for simulation and games can be said to have had good results in the U.S.A. and elsewhere compared to the results obtained in other school sectors of application. In the teaching of economics subjects the computer is already to be regarded as a necessary aid which helps to enhance both concretion and pupil motivation. The computer is used in this connection 1) to store information which is used for subsequent decisions, 2) to analyse portions of this information as required, 3) to produce simulation models giving the pupil a more concrete insight into the decision situations which frequently confront e.g. the manager of a firm.

The advantages of computerized simulator models are e.g. that they enable the pupil 1) to familiarize himself with the situation that arises, 2) to take decisions on a relatively realistic basis, 3) to perceive the consequences of those decisions in due course, 4) to make further decisions on the basis of this perception. One often neglected advantage is that the computer makes it possible for the pupil to obtain a pattern of action which he can follow in spite of the abundance of variables.

Other advantages offered by computer simulation and computerised games include the following:

1. Parts of subjects which today are pre-minently theoretical and are often presented in the form of descriptions, lectures, instructional lessons can be concretized in such a way as to enable the pupil to see how different structures are built up, how different quantities of data create trends and how he can take and see the results of certain decisions in the light of selected information.

2. Computerized simulation gives a simultaneous practice effect which is often lacking in the ordinary lecture or classroom situation.

3. When pupils are presented with relevant data and then placed in a situation where they have to make decisions, a high degree of motivation is created for their studies.

4. The pupil can work through the computerized game regardless of time and the availablilty of teachers.

Computerized simulation also provides an opportunity for practising a species of time-compression technique, i.e. a method whereby the pupil can telescope the time elapsing between two decisions. Thus the decisions which have to be taken by a managing director over a period of 20 years can be reduced to four hours or less with the aid of a computer. The time compression technique is often part of the simulation method and is used e.g. in connection with agricultural planning, in environment conservation and in other sectors. An experiment predominantly concerned with time-compression techniques is now in progress at the University of Michigan, where experts are being taught how to evaluate training programmes, school forms and systems. In other words, an attempt is being made to investigate and if possible predict the value of a certain instruction. The aim is to evolve by simulation certain methods or alternatives which are most suitable for the solution of a particular problem.

The computer provides the pupil with an opportunity of dealing with very complex relations which can include hundreds of variables and which he would otherwise have no chance of working on. Computerized simulation and computerized games can be regarded as a key or test sector of the educational potential of the computer. The experience gained so far is highly promising and on these grounds alone one can even go so far as to say that there is a future in the hidebound and much maligned computerized instruction which instead of utilizing this technique has often been occupied with presenting the pupil with a gobbet of information at a time and then asking questions and letting him give short answers. Computerized simulation harnesses the potential of the computer in a completely different way from so-called computer-assisted instruction.

Conclusion

Educationalists who have tested computerized simulation or computer-supported games have been highly favourable in their pronouncements. Computerized simulation is viewed practically unanimously as a sector with great development potential.

Summary: the computer as a pedagogical support and control member

This is a difficult sector to define. The computer activities involved are not peculiar to it. One of the commonest terms, CMI (Computer Managed Instruction) is highly ambiguous. Some American projects, e.g. the PLAN project, use the computer

merely as a feedback device which teachers and pupils can use to find out the pupils' test and examination resluts. The computer is also used to provide curricular instructions, directions and aids, teaching materials and suchlike.

In the PLAN project pupils are to work with conventional and commercial teaching materials which are not computer-based.

The IPI project also includes the above mentioned elements but combines them with computer supported teaching, i.e. the pupil is also given courses and material via the computer, including material specially constructed for the pupils taking part in the experiment. In the latter case elements of CAI (computer-assisted instruction) are also included.

The advantages which are thought to accrue from CMI are as follows:

1. Many time-consuming administrative and informative routines performed by a teacher in the classroom and outside it can probably be reduced or simplified through CMI.

2. The pupils' motivation for a subject is increased by prompt feedback, i.e. giving them the results of different tests and at the same time letting them know what more they should read to improve their knowledge, remedy their deficiencies or deepen their understanding of a subject.

3. CMI gives both teacher and pupil a better chance of individualizing instruction. There are good grounds for saying that teachers today have neither the time nor the administrative resources for more differentiated or individualized instruction)learning in the classroom or outside it.

4. Another advantage of CMI is that the teacher can immediately correct his teaching when he finds out how pupils have reacted in certain computer tests. Thus he can revise certain items, give certain pupils extra training and so on. Certain educationalists are of the opinion that CMI simplifies goal analysis. Others,however,are more critical and feel that goal analysis conducted with the aid of CMI is liable to attach undue importance to purely cognitive goals. This would give goal analysis an unwelcome cognitive bias.

There are, however, considerable difficulties to be overcome within the CMI sector. One such difficulty lies in deciding what data concerning the pupil are to be included in an individual system of CMI character. Thus certain experts feel that the data built up within the CMI system and consisting of test data of various kinds are sufficient. Others contend that data concerning the pupil's socio-economic background and his mental and emotional maturity should also be included. But it is very difficult, for reasons of discretion, for data of this kind to be included. Owing to our inadequate insight into the teaching

and learning processes, it is extremely difficult to produce a tailor-made system and assume that the pupil will be able to cope with a certain type of performance or with particular tasks or test items. It is even asserted that this prediction of the next step to be taken by the pupil is in itself a major problem.

CMI is not thought to work very well unless certain conditions are satisfied:

Teaching in the classroom and outside it must have been carefully planned and this can only be done in the form of a detailed analysis of what is included in the teaching concerned, i.e. the items involved, the methods and teaching materials that are relevant and available, and the capacity of the pupil category in question for independently coping with certain tasks. CMI presupposes a knowledge of what ought preferably to be presented in the classroom together with other pupils and what tasks are of a more individualized nature. By all accounts the CMI system constructed must be tailor-made to suit the pupils and the instruction involved.

Computerized marking or optical reading with the aid of a computer can be seen as a subsidiary sector of CMI. This form of computerization can involve the administration of certain tests to the pupil. The computer then registers the pupil's answers, marks them and works out the score. On the basis of his answers, the pupil is given a diagnosis of his knowledge at a particular moment. The test may be of a preliminary or diagnostic nature.

One quite promising venture is the so-called sequence testing which has been tried out at Florida State University. In this form of testing the computer programme takes into account not only the answers previously given by the pupil but also the degree of certainty and knowledge exhibited by him. The computer also registers answering times and the pupil is offered a certain test item in the next step based on his previous item.

This can mean that a pupil who answers very quickly or very well is given a special test item. It can also mean that a pupil who answers correctly and rapidly all the time is given a smaller number of test items. In this way the test stage or test can be abbreviated. This sector should be amenable to considerable development. Sequence testing is an extremely interesting aspect of developments in the field of computer-assisted-instruction.

The experiments conducted in the U.S.A. with computer-based study and vocational guidance have above all been aimed at making the pupil more motivated for the question of choosing a career and at the same time giving him a real chance of independently appraising study alternatives and occupational sectors. It has also enabled him to familiarize himself with

more sectors than would be possible in the time allotted to conventional teaching. The results so far are promising.

Conclusion

The National Board of Education should encourage and initiate research and development in this sector, especially as regards computer based study and vocational guidance. It is extremely difficult to keep the factual content of study and vocational guidance material up to date. It is also difficult to supply all pupils promptly with correct study and vocational guidance information.

The proposed pilot survey should therefore be made to include an inventory of current problems connected with computer-based study and vocational guidance.

Summary : computer-assisted-instruction (CAI)

Of all the subsidiary sectors considered in this Pilot Study CAI has involved the largest number of experiments and the heaviest research commitment. Most of the grants awarded in the U.S.A. for computer-based experiments in the educational sector have gone to CAI. In spite of the broad range of investment in research and development, many important problems still remain to be solved. Thus, no computer equipment is at present available at a price which schools can afford.

One often hears that the potential resources of the computer have not been fully harnessed in CAI programmes. The programmes developed for the computer have not differed very much as regards content and disposition from those already presented via simple teaching machines. The criticism formerly levelled against programmed instruction for not being well-integrated with other activities in the subject concerned can also be applied to CAI. The importance of a very careful choice of sections, items etc. with characteristics rendering them suitable for presentation and learning via computers has been stressed in many quarters.

Nonetheless there is every reason for high hopes e.g. regarding the CAI experiments included in the PLATO project at the University of Illinois. Don Bitzer, the PLATO project leader, has proceeded on the assumption that CAI (or as he terms it CBI/Computer Based Instruction) cannot be utilized within the educational sector until a radically simple, inexpensive and reliable pupil terminal has been developed. Another positive trend is that many researchers have now realized the importance of a careful choice of pupil category, subject and subject section for the application of CAI.

Conclusion

Technically speaking, a simple and inexpensive pupil terminal with CAI screen and sound equipment has yet to be developed. Pedagogically speaking it still remains to develop CAI programmes utilizing the potential teaching resources of the computer.

3 Computer education

The reason why computer education has been broached in this context in the first place is to be found in the possibilities of combined utilization of computer equipment, systems and software and the interchange of computer activities and computer experience that could occur between computer education and other computer activities in school.

The rapid technical development of mini-computers together with greatly reduced prices (an annual reduction of between 25 and 50 per cent is said to be likely) makes it possible for computer equipment to be used for computer orientation e.g. in the technical line of upper secondary school. In this way a bridge can be thrown between computer orientation and computer-managed instruction, e.g. by the utilization of the computer as a calculator or as an aid to simulation and games.

3.1 Computer training

At present computer training is vocationally oriented and takes the form of a higher specialized course for programmers and systems men. This course is held at about fifteen upper secondary schools. This training is in need of extension, in the first instance so as to include real-time-techniques. This in turn raises the need for terminals/mini-computers for instructional purposes. If such equipment were to be acquired for upper secondary schools, computer equipment could be shared by the various data activities occurring in schools.

3.2 Computer orientation

Pursuant to the letter of 30.6.71 from the King in Council, an internal working party has been set up at the National Board of Education to investigate the appropriate manner in which computer orientation can be designed in comprehensive and upper secondary schools. The working party is also to arrange for the compilation of syllabi and more detailed instructions for the conduct of computer orientation. Experimental activities will probably be proposed for testing syllabi.

The experiences reported by Swedish schools which have used computer equipment reveal that the computer is extremely useful for calculation tasks and simulation support in technical and scientific subjects. Experience of the use of the computer as a calculator in combination with computer orientation will be derived from the joint experimental activity begun during the autumn by the City of Stockholm Education Authority and the National Board of Education.

4 The potential applications of the computer in Schools - summary

So far only limited use has been made of computers and computer techniques in schools. Computers have been mostly employed for purposes of school administration. Many school districts in the U.S.A. have computerized the registration of teachers, other school personnel, pupils, merit reports etc. In Sweden it is mainly municipal schools for adults that have computerized certain registration tasks. Planning and administration in schools today are in great need of rational aids. There would appear to be good prospects of computers being used in school planning and administration with a view to rationalization.

For some years now, computer-based information and documentation systems (IoD systems) have been used in technology, medicine and education in the U.S.A., Sweden and other countries. The Swedish LIBRIS system contains the embryo of a common computer based information system for Swedish research libraries.

The computer already plays a certain part in teaching as a calculation aid, especially in the case of technical and scientific subjects requiring extensive calculations. The computer used as a calculator is regarded in the U.S.A as an indispensable aid in higher education. Computer-supported games and computer-based simulation are another sector which can display promising results and which evinces great development possibilities.

The computer used as an educational support and control member is thought to offer help in time-consuming administrative and informative routines which are often incumbent on teachers, but there are certain difficulties that will have to be overcome before the computer can play a more important part.

One interesting sub-sector is study and vocational guidance, where relatively promising results have been obtained using computer based systems. At present, using conventional methods, it is difficult to give all pupils correct study and vocational guidance information. Computer techniques may prove extremely helpful in this respect.

Most experiments within the DIS sector have been concerned with computer-assisted instruction (CAI). One frequent criticism has been that the potential resources of the computer have not yet been harnessed in CAI. New attitudes are gaining ground, however, and the University of Illinois PLATO project, among others, shows a certain amount of promise for the future.

As regards the teaching of computer techniques (computer instruction), a new form of training (instruction in real-time programming) is needed in computer training. This in turn

calls among other things for terminal equipment. The prime requisite for computer orientation in comprehensive school and upper secondary school is syllabi and more detailed instructions concerning the organization of teaching. Access to some form of computer equipment is also desirable, particularly in upper secondary schools.

6 Measures proposed

Computer techniques are developing at increasing speed. Computer capacity is increasing at the same time as apparatus is becoming less bulky (mini-computers) and prices are falling steeply. This trend will probably result in computers becoming a standard item in the educational sector within the near future

It is therefore high time that the National Board of Education began to grapple seriously with the problems which will fairly soon arise when computer techniques begin to be harnessed on a large scale for both administrative and educational purposes in the school sector. There is already an urgent need for the accumulation by the Board of a fund of know-how in readiness for the probably revolutionary changes that the increased use of the computer will entail.

Ten years' American experience in the DIS sector with a commitment of several hundred million dollars has failed to produce the results that were hoped for. To a great extent this is because developments have moved too quickly in relation to technical equipment, costs etc. and because the computer has been used in an excessively conventional manner, i.e. as an aid, without utilizing its potential resources and without applying it to the special tasks existing in schools and the educational sector. But the main cause would seem to lie in diffuse, unco-ordinated experiments with no central body to co-ordinate the various projects.

The National Board of Education, together with the two associations of local authorities should therefore act on American experiences as soon as possible by tackling the entire range of problems arising when efforts are made to utilize the computer for several different purposes in individual schools and types of schools with different sponsors which can nonetheless pool computer resources and experience. The Board should endeavour to direct developments in the DIS sector and to do so together with the associations of local authorities, who for obvious reasons are bound to be the main interested party with regard to the local and regional data activities which can come into question.

Together with the associations, the Board should initiate a pilot survey to provide a more concrete inventory of activities in school administration and teaching which can be successfully

computerized. The pilot survey group which it is thus proposed to set up should also investigate the practicability of model experiments in a particular municipality. If such experiments are deemed practicable, the project group should also compile suggestions for experimental activities (model experiments).

The proposals put forward concerning an investigation of the utilization of computers in the study and vocational guidance sector (see item 6.2) should be borne in mind and if possible incorporated in the pilot survey.

Other measures may also be called for on the strength of the pilot study.

As regards computer orientation, pursuant to a letter from the King in Council dated 30.6.71, an internal working party has been set up within the National Board of Education mainly for the purpose of drawing up syllabi and more detailed instructions regarding computer orientation in comprehensive school and upper secondary school.

In this connection the DIS group feel that particular emphasis should be placed on the following:

Consideration should be given to the possibility of pooling computer equipment. In view of the exceedingly rapid pace of technical development in this sector, it is reasonable to suppose that mini-computer equipment which is quite expensive at present will come within the course of a few years to occupy the same price class as electronic calculators today. Apart from administrative and purely instructional tasks, it should also be possible to use the same equipment for computer orientation. It is extremely important for opportunities for pooling computer resources in schools and municipalities to be taken, especially in the early stages. The pilot survey proposed above must therefore be planned in such a way as to shed light on these matters.

One of the major problems in computer orientation concerns the in-service training sector. At present both comprehensive school and upper secondary school teachers have little knowledge of computer techniques and their effects and they must therefore be given in-service training on the subject. This is particularly true of mathematics, physics, electricity and civics teachers in upper secondary school, who need to be given comprehensive in-service training to enable them to teach their pupils about computer techniques. Suitable in-service training material will also have to be developed. The National Board of Education should also arrange for the production of computer orientation teaching materials which can be used in comprehensive school and upper secondary school.

6.1 The project "Computers in the School Municipality" - draft project plan

Background

So far computers have been used experimentally in schools for a host of different tasks. The following sectors of application were enumerated in Pilot Study Report 2:

1. The computer in administration and information

1.1 schcol administration

1.2 information and documentation systems

2. The computer in teaching

2.1 Computer-supported instruction

2.1.1 the computer as calculator - computer-supported simulation

2.1.2 as an educational support and control member

2.2 computer-assisted instruction (CAI)

It is emphasized in many connections that computer techniques have been found to require heavy personnel and material investments. This should be a major consideration within the school sector, for, compared to a firm or enterprise about to introduce computer based systems, schools and the educational sector present what from the point of view of computer systems is a rather complex structure. Moreover relatively little experience has so far been gained of the use of computers in schools.

One fundamental condition for the successful utilization of computers in the school sector would therefore seem to be a carefully study together with comprehensive planning of the sector in which it is proposed to introduce computer based administrative or instructional systems. This study should also include an investigation of the possibilities of computer resources used in one sector also being applied to another, i.e. of bridging the gaps between sectors.

The basic idea of bridging the gaps between different spheres of application is an important item in the proposals for experimental activities with "Computers in the School Municipality" outlined below.

Summary of the motives for the project "Computers in the School Municipality"

1. Experience of the administrative utilization of computers in a school municipality is of interest to all school municipalities and, accordingly, for central planning and information as well.

2. Experience of the computer as an aid to teaching, i.e. the educational role of the computer (e.g. jointly with the utilization of computers for administrative purposes) is of the utmost central interest.

3. The introduction of computers in the school municipality also has a bearing on information to teachers and pupils regarding computer techniques. The National Board of Education is increasing its commitments in the field of computer studies or computer orientation. Experience of this implementation of computers will be of value to the entire DIS sector.

4. A large number of municipalities and computer firms have expressed interest in taking part in projects in the DIS sector. Projects conducted independently and without any coordination are liable to result in separate computer systems which are not even partially susceptible of general application. Great importance must be attached to the initiation by the National Board of Education, together with the associations of local authorities, of experiments leading to generally applicable solutions.

Aim of the project

The aim of this pilot survey is to decide whether computer techniques can help to effectivize and rationalize local school administration activities and also to determine which routines can profit by using the same or parts of the same computer capacity. These may include certain tasks of school administration, e.g. teacher and pupil registration, and certain pedagogical activities, e.g. within the study and vocational guidance sector (see item 6.2), computer-supported simulation etc. The computer activities investigated should be such as can be said to be of general interest. Typically local elements should be avoided.

A pilot survey due to begin during the spring of 1972 will investigate the possibility of experimental activities to test the following working hypotheses:

The introduction of computer based systems will mean:

1. Better information retrieval for planning and administration

2. Greater efficiency in school administration

3. Better resources for the individualization of instruction

Pilot survey

The pilot survey due to begin in the spring of 1972 will investigate the conditions for the utilization of computers in a model municipality (suitable population 70 000 - 100 000).

The aim of this pilot survey is

to describe problem sectors

to describe possible rationalization measures

to draw up a cost estimate.

With a view to a possible implementation on a larger scale, the model experiment (main study) will also provide a basis on which to decide, among other things

1. To what use the computer can be put by the school municipality in school administration and pedagogical administration.

2. The potential use of a mini-computer/terminal in school and in the municipality.

3. The importance and value of access to a mini-computer/terminal for computer training and orientation in comprehensive school and upper secondary school.

4. The importance and value of access to a mini-computer/terminal for in-service computer training for teachers.

Basic outline of the project

The pilot survey designed to investigate the possible use of computers is being jointly conducted by the National Board of Education and the associations of local authorities. A special working party, "the pilot survey group" is being set up (composition etc. overleaf).

One of the tasks of the pilot survey will be to determine the practicability of a model experiment in the municipality. If such an experiment is found to be practicable, the project group will go on to draft a plan of experimental activities (model experiments). As the main study proceeds, further decisions will be successively taken concerning the design and possible continuation of the experiment.

Rough time schedule

Pilot survey	spring term 1972 - autumn term 1972
Design of the experiment (main study)	autumn term 1972 - spring term 1973
Commencement of model experiment (on a limited scale)	autumn term 1973 - spring term 1974
Model experiments (full scale)	autumn term 1974 - spring term 1975
Revision of routines, evaluation	autumn term 1975 - spring term 1976
Follow-up, final report, decision	autumn term 1976 - spring term 1977

Project organization

The pilot survey is being conducted by a project group, "the pilot survey group", comprising planning, systematization and educational expertise. The pilot survey group is being nominated by the National Board of Education together with the associations of local authorities. The work of the pilot survey group will be directed and accounted for by the DIS group together with representatives of the associations of local authorities and the National Office for Administrative Rationalization and Economy.

The question of a new main study and a new project organization will be determined by the National Board of Education and the associations of local authorities in the light of the results of the pilot survey.

It is important for the pilot survey group to take note of activities in the DIS sector which are in progress elsewhere (e.g. at the National Board of Education). Thus matters concerning the use of computers for information retrieval e.g. in central and local planning and administration come within the PLAN and INFO spheres of operations, so that the work of the pilot survey group should be made to tie in with surveys at present being conducted by those working parties.

Assuming that the pilot survey group recommends a main study within the sector, guidelines and more specific directives for a model experiment will be drawn up by the DIS group in collaboration with the associations of local authorities and the National Office for Administrative Rationalization and Economy. The DIS group will also put forward proposals regarding the composition of a project group and steering committee for the main study (model experiment).

Once practical operations begin to be established in a large number of schools, it is of the utmost importance for the

hardware to be sufficiently uniform to permit the use of the same programme ware. A strict centralization of development work and purchasing is thus called for. The National Board of Education, the associations of local authorities and the National Office for Administrative Rationalization and Economy should be given a deciding influence in this decision process.

Costs

At present only the costs of the pilot survey can be accounted for. The pilot survey is expected to require about six months' work.

Outside personnel:

school administrator	6 personnel months x 7 000:-	42,000:-
planning expert	6 personnel months x 7,000:-	42,000:-
systematization expert	6 personnel months x 7,000:-	42,000:-
study and vocational guidance expert (see item 6.2)	4 personnel months x 6,000	24,000:-
		150,000:-
Lkp		36,000:-
		186,000:-
travel expenses		10,000:-
miscellaneous costs		15,000:-
	Total Skr	211,000:-

6.2 The computer in study and vocational guidance - survey proposals

Background

One of the aims of the study and vocational guidance (shortened: syo) programme is to give pupils allround objective information on educational opportunities, working life and the labour market and to teach them to make critical and independent use of this information in choice situations during their school careers and subsequently. This material is very extensive and varied in character and considerable pedagogical problems are encountered e.g. in the teaching of decision techniques. Efficient

individualized instruction in this context presupposes an abundance of teaching and guidance time, often more than is feasible in present-day conditions. This makes it natural to consider whether the capacity of the computer for providing immediate and comprehensive information in large quantities and for presenting sectors of information in varied combinations could not be utilized by pupils, teachers and counsellors. In the U.S.A. favourable experience has been gained of the use of computers in the syo sector. We therefore propose that closer consideration be given to the following project suggestions.

The computer as an individual aid for information concerning work tasks and working conditions

One of the aims of vocational guidance in schools is to teach pupils to locate, analyse and assess information concerning different occupations and educational opportunities in relation to their own desires, interests and aptitudes. To this end efforts are made to start with a discussion of different types of work tasks ("occupational functions") occurring in various combinations in different occupations and of working environments end spheres of activity. See e.g. Fb SYO 2b; "Choosing for Yourself". This means among other things that pupils should be actively trained in formulating individually relevant "search questions" and making use of various kinds of careers information. Different kinds of training booklets and other teaching materials are used for this purpose, see e.g. the work brochure "Teach Yourself to Choose Vocational Practice".

The source material containing the facts used for this purpose is very large and consists of many publications offering different kinds of information and emanating from different publishers. The basic material consists of the Labour Market Board's publications Swedish Occupational Cyclopaedia, Your Job and Your Future, and Employment Information together with informative publications on educational and training opportunities issued by the National Board of Education and other organizations. Other kinds of material, e.g. from firms and trade organizations, are also used. This means that information retrieval (which is often conducted in the form of group work) can take up a great deal of the pupils' time, in addition to which teaching and the above mentioned skill of formulating meaningful "search questions" are bound to be more illustrative than comprehensive.

Accordingly there may be good grounds for an investigation of the extent to which a supplement to the literature in the form of computer-based material could simplify teaching by giving rapid answers to pupils' questions, correct references to sources of information etc.

The computer material and its utilization

Basically the computer material would be organized on the same lines as in documentation work. The items would of course be occupations and educational opportunities described by several concepts, e.g. occupational function, sphere of activity, working environment, educational level, labour market characteristics. By formulating individual search questions in the concepts included (variables) under the teacher's guidance and testing them (individually or in groups) in the computers, pupils could rapidly otbain and compare different groups of occupations and also obtain references for further information.

Anticipated effects

The use of computers could make for greater individualization of instruction to suit the interests and ability of the pupil and it could also facilitate a more exhaustice presentation of material. It would also relieve the teacher of a great deal of pure fact collection and material handling, thus enabling him to concentrate more on the fundamental task of teaching pupils how to put their questions regarding the choice of studies and occupations. An experiment in this direction would result in a general increase in pedagogical knowledge, since it concerns a concept formation learning which differs somewhat from "ordinary" fact learning.

The computer would seem to be by far the most efficient aid for a search process of the kind referred to above. Reference works and other printed items cannot be grouped with the requisite number of "entrances" without becoming very unwieldy in the process. The needle card or sight hole card registers now generally used as office aids can only give references, not factual information, apart from which they soon wear out.

It should be noted in this connection that computer applications of this kind require an extensive memory and combination capacity, which is exactly what the computer has to offer.

Working party

An expert is being nominated to collaborate with UA 3, the DIS group and the Labour Market Board in studying (it is suggested that the study comprise two stages) and submitting proposals on the subject as follows.

1. Development and definition of the goals of the teaching concerned, i.e. to provide pupils with a broad view of working life, free them from the "individual occupation mentality" and teach them to ask the right questions.

2. Outline (in consultation with the vocational guidance bureau of the Labour Market Board) of the system of variables with respect to the educational goal.

3. Outline of the pedagogical interaction of teacher, pupil and computer together with an investigation and suggestion of a suitable form of data presentation.

Once items 1 - 3 have been completed, an assessment can be made of the feasibility of experimental activities. If it is found that experimental activities can begin, planning of the same can start with the following measures:

1. a definition of the factual sector according to the type of school, study alternative and level to which the experiment should refer

2. the investigation and suggestion of solutions for

    1. the establishment of a data base

    2. choice of hardware, development of systems ware including search programmes

3. the compilation of a cost estimate for an initial experiment

4. the compilation of guidelines for possible experimental activity, taking into account updating problems etc.

The survey should if possible be co-ordinated with the project "Computers in the School Municipality".

Costs

1 expert x 4 months x Skr. 6,000	Skr 24,000
travel	Skr 4,000
	Skr 28,000

SUMMARY of Pilot Study 2

Hitherto computers and computer technology have not been utilized on any considerable scale in schools and the educational sector. The capacity of the computer has, however, been applied on an experimental basis to a variety of tasks. The following sectors are covered by this report:

1. Computers in administration and information

1.1 for school administration

1.2 in systems of information and documentation

2. The computer in teaching

2.1 computer-supported teaching

2.2 computer-assisted instruction (CAI)

3 Computerized teaching

Most of the experiments with computers and the application of computer techniques described in the following report have been conducted in the U.S.A,, though a number of Swedish experiments are also included. (Reference is made in certain cases to experiments described in earlier reports (pilot study 1 and report on a study trip in the U.S.A.). The summaries given regarding each sector are based on all three reports.)

So far the commonest application of computers has been for purposes of school administration. Many school districts in the U.S.A. have computerized registers of teachers, other school personnel, pupils, merit reports etc. Clearly there is every possibility of computers being used for purposes of rationalization within the contexts of school planning and school administration.

Computerized information and documentation systems occur in technology, medicine and pedagogics. The Swedish LIBRIS system contains the embryo of a common information system for Swedish research libraries.

The computer is already playing a certain part as a calculator e.g. in technical and scientific subjects where pupils have to work with complex mathematical quantities. Computer-aided simulation techniques have been used with great success and there would appear to be good possibilities of further development within this sector.

As an educational support and control organ, the computer is regarded as a potential aid in the time-consuming administrative and informative routines which are often incumbent on teachers. There are however certain difficulties which will have to be overcome before the computer can play a more significant part in this context. One interesting sub-sector is that of computerized study and vocational guidance.

Most of the experiments in the DIS sector have employed computer-assisted instruction (CAI). In spite of heavy investment, little success has been scored in the majority of cases in utilizing the potentialities of the computer. A new attitude is emerging, however, with regard to the development of software utilizing the pedagogical resources which the computer can be said to offer. Consequently there is every reason for a close observation of developments in the CAI sector.

A new form of training (realtime programming) is needed for the teaching of computer techniques. Syllabi and further training for teachers are the most urgent requirements for a presentation of computer techniques in comprehensive school and upper secondary school.

Technical developments in the computer sector are moving fast, particularly as regards so-called mini-computers. Prices are falling rapidly, thus increasing the prospects of computers being utilized by schools within the relatively near future.

Experience from the U.S.A. should be utilized by the National Board of Education and the two associations of local authorities acting as soon as possible to gain an overall view of the problems encountered when attempts are made to employ computers for many different purposes in different schools and types of schools whose various sponsors in many cases can nonetheless pool their computer resources and experience. Together with the associations of local authorities, the National Board of Education should initiate a pilot survey to obtain a more specific inventory of activities in school administration and teaching which can be successfully computerized. The pilot survey group thus proposed should also investigate the feasibility of a model experiment in a particular municipality. If possible the pilot survey should also incorporate a proposal for an investigation of the utilization by the DIS group of computers in study and vocational guidance.

As regards the presentation of computer techniques, the National Board of Education, pursuant to a letter of 30.6.71 from the King in Council, has set up an internal study grour whose main task will be to compile syllabi for a suitable presentation of computer techniques at comprehensive school and upper secondary school levels. It is important in this context for due consideration to be given to the possibilities of pooling computer equipment. It is also highly important for arrangements to be made as soon as possible for the further training of comprehensive school and upper secondary school teachers and for the compilation of suitable further training material.